SCIENCE

AEROSPACE ENGINEERING

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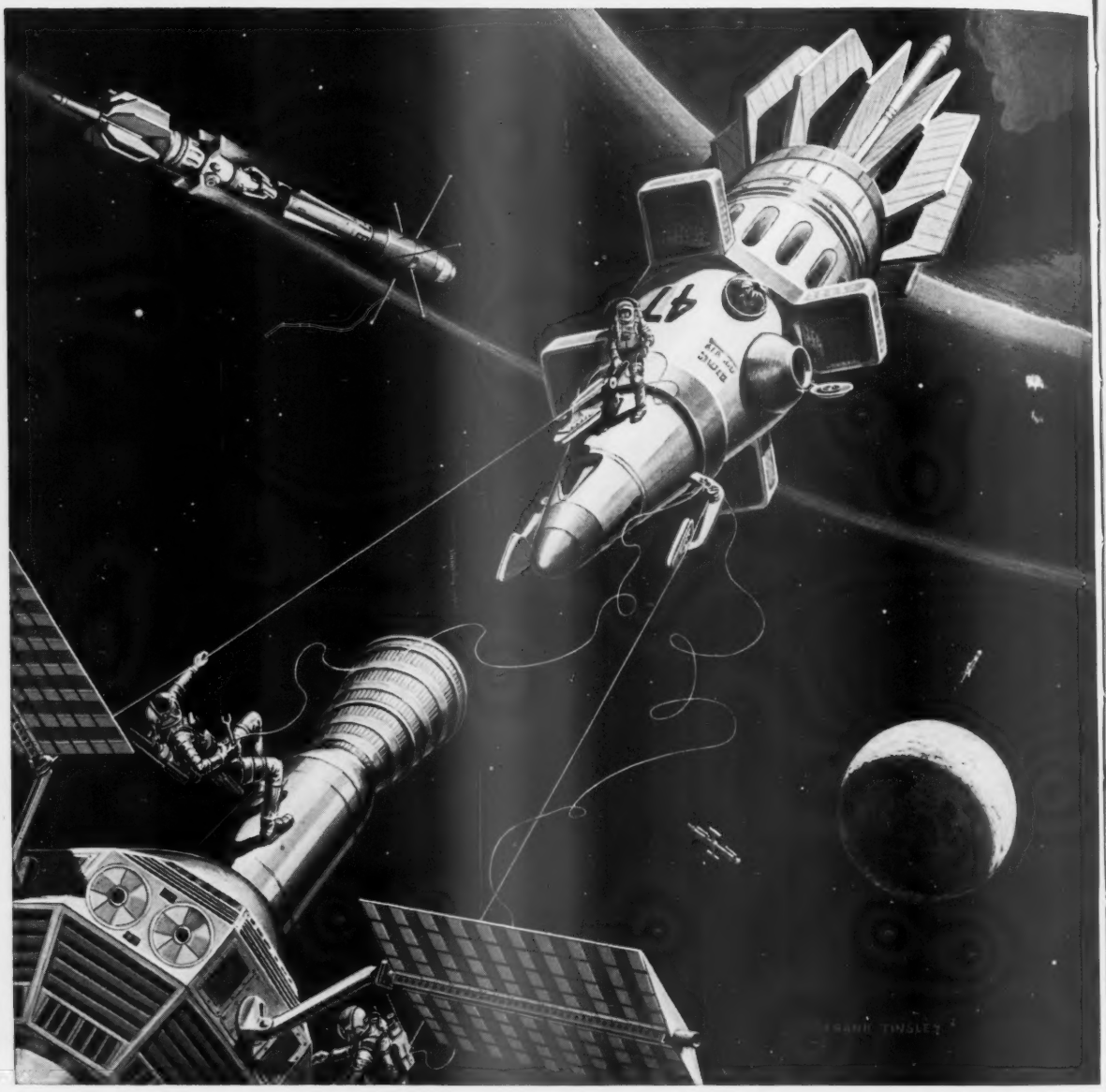
Institute of the Aerospace Sciences

Editorial . . . p. 25

SCIENCE

AUGUST / 1960



STEPS IN THE RACE TO OUTER SPACE

Breaking a Space Traffic Jam

By 1970 our solar system will be filled with expended satellites—whirling aimlessly in space with dead batteries and electronic equipment, their missions long since completed.

As space traffic increases, these derelicts will have to be captured and broken out of orbit to keep flight paths clear. For this task, special towboats will be designed and crews trained.

Here, step by step, is an account of such satellite capture and destruction:

1. The towboat, driven by electro-particle propulsion, rockets into space at speeds reaching 25,000 m.p.h. Its reversible engines enable it to slow as it approaches the radar-located satellite, and match the derelict's speed as it moves into orbit behind it.

2. Crewmen attach lines to the satellite (as in illustration). Then they haul the towboat forward and its nose cone is clamped to the satellite's rocket nozzle.

3. The towboat's engines are then switched to full reverse and the linked machines gradually lose momentum, nosing into a spiral path toward the Earth below.

4. When a safe point is reached, the towboat automatically releases the satellite and it is consumed by friction as it plunges into the heavier atmosphere. The towboat, regaining its speed, moves on to its next assignment—breaking a traffic jam in some other congested point in space.

ARMA, now providing the inertial guidance system for the ATLAS ICBM and engaged in advanced research and development, is in the vanguard of the race to outer space. For this effort, ***ARMA*** needs scientists and engineers experienced in astronautics. ***ARMA***, Garden City, New York. A Division of American Bosch Arma Corporation.

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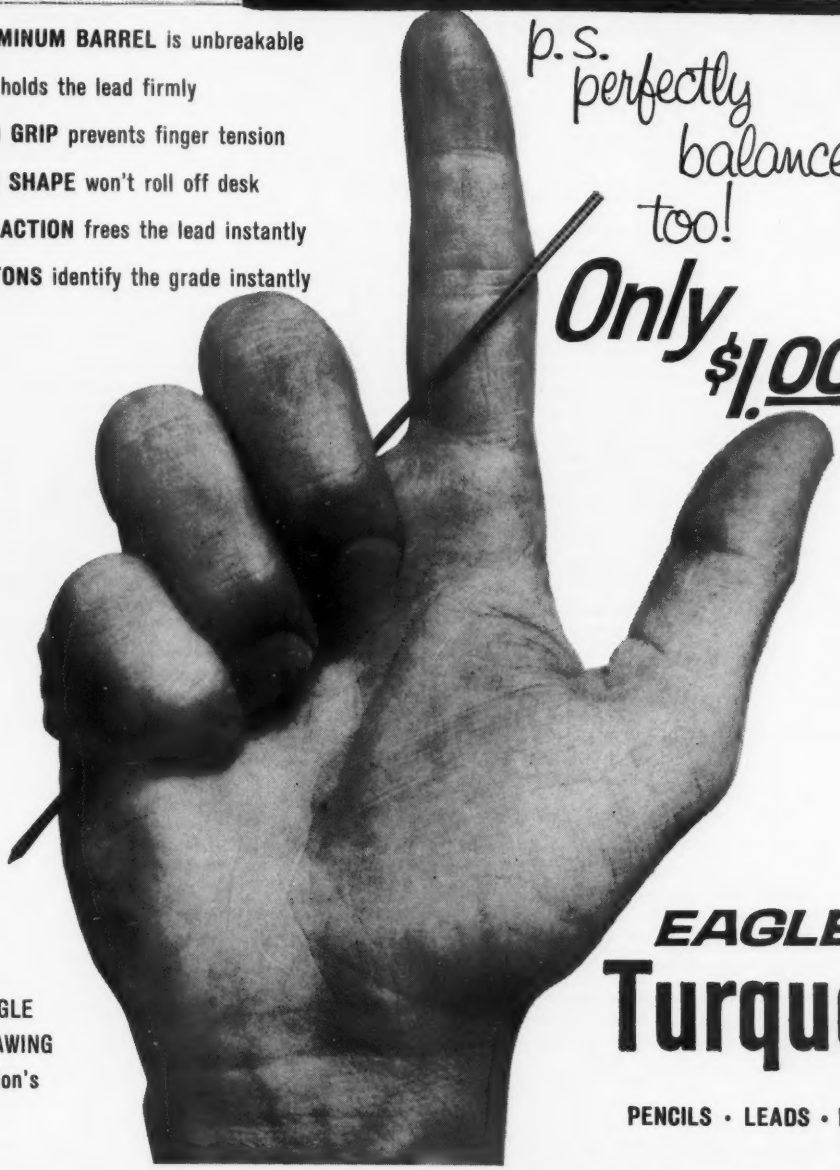

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ON OUR COVER . . .

New in-flight refueling station for Marine Corps jet fighters is this 67-ton Lockheed GV-1 prop-jet-propelled tanker. Two advanced A4D attack jets hook up to the GV-1 to take aboard fuel. The tanker is the latest adaptation of the C-130B Hercules and carries 10,560 gal. of jet fuel. Flying at jet altitudes and speeds, it is capable of refueling two jet fighters simultaneously in 3 to 4 min., according to Lockheed's Georgia Division. Paradrogues used to feed fuel to planes are trailed from pods under the GV-1's wings.

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IAS AEROSPACE TECHNOLOGY PANELS

The members of the IAS Aerospace Technology Panels shown here are to be available, collectively or as individuals, to assist and advise IAS committees, Sections, and staff members as to currently interesting and important technical topics related to their specialties and as to people most qualified to speak or write on such topics. The panels will also stimulate thought and scientific papers of potential value for the future, and they should be sensitive to technical activity of other professional groups, seeking through joint action the enlightenment of all having professional aerospace interests. Panel chairmen are indicated with an asterisk (*).

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Raymer E. Schreiber
Ted Taylor
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IAS News

. . . a record of people and events of interest to Institute Members

Air Logistics Conference Scheduled for October in Tulsa

Plans for 3-Day Midwestern Meeting Include Field Trip to Airline Maintenance Base

THE EXCHANGE of the latest ideas in air logistics, to promote a more thorough understanding of the problems involved and to stimulate consolidation of practical solutions, will be the theme of the Institute's 1960 National Midwestern Conference. Five technical sessions and a field trip are on the agenda for the Air Logistics Conference to be held October 3, 4, and 5 at the Mayo Hotel in Tulsa, Okla. Luncheons are planned for the first 2 days, and a banquet is scheduled for the evening of Tuesday, October 4.

A committee composed of members of the Tulsa Section, headed by Meeting Chairman T. K. Petersen and Cochairman S. G. Weir, both of Douglas Aircraft Co., Inc., is making arrangements for the conferences. Russell W. Brown, also of Douglas, is Section Chairman.

Technical Sessions

The first session scheduled for the morning of Monday, October 3, Growth and Forecast, will establish the basis for developing an efficient air logistics system. Papers on commercial, military, and international air cargo will review the current status and the future outlook, highlighting the facts of the situation and establishing the problem. Dr. Paul Cherrington of Harvard University is session chairman.

The afternoon session, chairmanned by Col. Lucian Rochte, Jr., of the Federal Aviation Agency, will define the specific requirements of an air logistics system tailored to commercial and military operations.

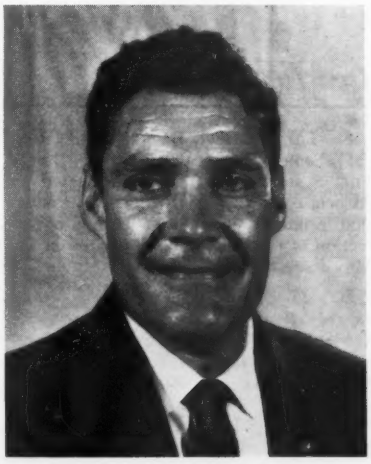
The third session on the Cargo Aircraft, with J. B. Edwards of Douglas as chairman, will present a discussion of the compatibility of the technical design requirements and the state-of-the-art capabilities. Another aspect of the discussion will cover the planned developments and their impact on the expressed needs of the military and commercial carriers.

A presentation encompassing past experience and "futuristic" thinking concerning ground handling systems will be the topic of a session chairmanned by R. W. Rummel of Trans World Airlines, Inc. In the final technical session, a summary panel on Air Logistics Planning and Developing, panel members will present their views on the direction which should be taken to ensure the development of an air logistics system, with an eye toward formulating a plan for developing an efficient airlift system.

Field Trip

The meeting will conclude with a field trip to American Airlines' Maintenance Base in Tulsa on the afternoon of Wednesday, October 5, for demonstrations of actual logistics hardware.

Russell W. Brown
Tulsa Section Chairman



T. K. Petersen
Meeting Chairman

Helicopter Society Honors President Eisenhower, Six Others, at 16th Annual Forum Dinner

The Honors Night Dinner of the American Helicopter Society's 16th Annual Forum, held May 12 in Washington, D.C., was the occasion for the presentation of four permanent awards and two Honorary Fellowships in the Society, in addition to a special award to the President of the United States, Dwight D. Eisenhower.

The plaque presented to the President by AHS President Ralph P. Alex and Awards Chairman Charles Kaman, cited Mr. Eisenhower for "regular and extensive use of the helicopter focusing world attention upon the ease and reliability with which rotary-winged aircraft can reduce to minutes trips that by surface travel might be measured in hours, and for introducing the benefits of helicopter transportation to other heads of state, further confirming the helicopter's dependability and advancing its cause as the most versatile vehicle yet devised by man."

Among the permanent awards presented was the Capt. William J. Kossler Award, to Marine Helicopter Experimental Squadron One (HMX-1), U.S. Marine Corps Air Station, Quantico, Va., accepted by Lt. Col. Victor A. Armstrong, and to Executive Flight Detachment, Davison U.S. Army Air Field, Fort Belvoir, Va., accepted by Major William A. Howell. This award was given to these two organi-

zations "for their consistent demonstration of helicopter convenience and safety through the regular transportation of the President of the United States and other government officials."

V. Keith Putnam, U.S. Army Transportation Corps, Deputy Commander, Aviation Test Activity, Edwards AFB, received the Dr. Alexander Klemin Award "for achievements in advancing flight test procedures and techniques used in helicopters and other VTOL aircraft."

The Society's Frederick L. Feinberg Award, recently established by Charles H. Kaman to honor the memory of a former Kaman Aircraft Corp. test pilot, was presented to Major William C. Davis, USAF, and to Capt. Walter J. Hodgson, USAF, "in recognition of their new world altitude record in Class E1D helicopters, exceeding the previous record by over 8,000 feet."

The Grover E. Bell Award was presented to Igor A. Sikorsky, Engineering Consultant, Sikorsky Aircraft Division, United Aircraft Corp., "for his outstanding pioneering work in the development of the crane helicopter."

Honorary Fellowships in the AHS were bestowed upon John O. Emmerson, Vice-President—Engineering, The Kaman Aircraft Corp., and Igor Sikorsky.

Hughes Aircraft Company New Corporate Member

Hughes Aircraft Company, one of the nation's large military electronics manufacturers, has joined the IAS as a Corporate Member. Hughes employs approximately 29,000 persons at seven major facilities in California, Arizona, and New Mexico. It is owned by the Howard Hughes Medical Institute, a nonprofit foundation for medical research.

In the aerospace field, Hughes developed the Falcon, the world's first operational air-to-air guided missile, and the radar armament control systems for launching it. The company has produced more than 12,000 armament systems and many thousand Falcon missiles in equipping all-weather interceptors of the North American Air Defense Command.

Hughes is a prime contractor for the production of inertial guidance systems for the Navy's Polaris missile. It is engaged in development and manufacture of advanced communication systems for the Air Force. In the field of advanced radar and data handling, it is developing and producing mobile air defense and missile-launching systems for the Army, Navy, and Marine Corps.

In other areas, Hughes is engaged in R&D in the fields of infrared devices, computers, semiconductors, microwave products, satellite communications, miniaturization, nuclear electronics, ballistic missile defense, and space vehicles.

Langley Director's Post to Floyd Thompson

Dr. Henry J. E. Reid, FIAS, has relinquished his position as Director of NASA's Langley Research Center, a position he held for more than 34 years.

Ben W. Badenoch (M), General Manager of the Aero Hydraulics Division, Vickers Incorporated, was recently elected a Vice-President of the Company.

Floyd L. Thompson, FIAS, Associate Director for the past 8 years, succeeds Dr. Reid as Director. Dr. Reid will continue at Langley during a transition period in an advisory capacity to the new director, as Senior Staff Associate.

The change was made at Dr. Reid's request in order that, in view of his approaching retirement, direction of Langley's programs now in formulation be placed in other hands at the earliest practicable date.

L.A. Section Plans Space Symposium

The Institute's Los Angeles Section has planned a 2-day symposium on "Recovery of Space Vehicles" to be held at the IAS Building in Los Angeles, August 31 and September 1. The meeting, which is classified and requires security clearance for all who plan to attend, will cover re-entry, search and retrieval, deceleration devices, landing systems, re-entry vehicle structure, and vehicle overall design.

N.Y.U. Confers Honorary Degrees on von Kármán, Astin

Dr. Theodore von Kármán, Honorary Fellow and Founding Member of the Institute, received the honorary degree of Doctor of Science from New York University at graduation ceremonies held in New York on June 8.

The citation accompanying Dr. von Kármán's degree follows:

"Theodore von Kármán, Chairman of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organization, is the chief appraiser of advances in aeronautical science applicable to Western defense. A world-renowned flight dynamicist in this wondrous age of cosmic ballistics, it was he who years ago forecast breach of the sound barrier by manned aircraft and has since done more than anyone else to bring it to pass; likewise his impact on the development of rocketry and guided missiles as deterrent factors for peace has been primordial. The son of an eminent Hungarian philosopher and a graduate of Budapest Technical and Göttingen Universities, who elevated to supremacy that fountainhead of early German air strength, the Aeronautical Institute of Aachen, and who, providentially transplanted to America, made even greater gains for aviation as director for some twenty years of the Guggenheim Aeronautical Laboratories of the California Institute of Technology, he has soared to the pinnacle of achievement in a scientific discipline that conditions the future of humankind. With profound respect for genius directed to the preservation and enhancement of man's peaceful domain we would add to the treasury of honors that have so deservedly come to him from the ends of the earth our doctorate of Science."

Dr. von Kármán's close association with the IAS has been illustrated by his active participation in its meetings and publications. He is, in addition, President of the International Council of the Aeronautical Sciences, which is holding its Second International Congress in Zurich next month.

In the same ceremonies, Dr. Allen V. Astin (HM), Director of the National Bureau of Standards, was also awarded an honorary Doctor of Science by N.Y.U.

IAS *News*

News of Members

Sq. Ldr. Laurie J. Bayliss, RAF (Ret.) (M), Senior Technical Author for Dowty Fuel Systems Ltd., has been elected an Associate of the Institution of Production Engineers, London. This is a correction of the item which appeared in the May issue of AERO/SPACE ENGINEERING.

H. M. DeGroff (AF) has been named Head of Purdue University's new School of Aeronautical and Engineering Sciences, and Director of the Aero-Space Sciences Lab. Prior to this new assignment, Dr. DeGroff headed the University's School of Aeronautical Engineering.

Sir George Edwards (HF), Managing Director of Vickers-Armstrongs (Aircraft) Ltd., has been named an Honorary Fellow of the Royal Aeronautical Society, the highest honor the Society confers. Sir George is a past president of the RAeS.

Saul Feldman (M) has joined Electro-Optical Systems, Inc., as a Principal Scientist in the Fluid Physics Division. Dr. Feldman was previously associated with the AVCO-Everett Research Lab.

David Fourney (M) has been appointed to Texas Instruments Incorporated's Apparatus Division to provide customer service in the Los Angeles area. Prior

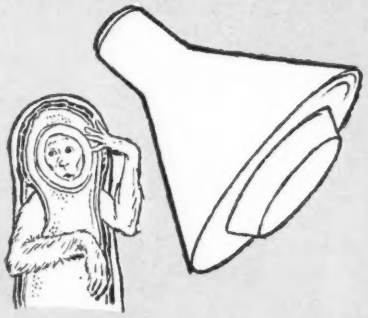
Consistently successful flight performance in Project Mercury confirms unsurpassed reliability of THIOKOL solid rocket motors.

Time after time, NASA's workhorse, Little Joe, has soared into space, checking out the workability of materials, propulsion and escape systems, and reaction of research animals to the environment of space flight.

Pollux, Recruit, Castor—solid rocket motors from THIOKOL's Elkton and Redstone Divisions—have unfailingly provided the thrust and power for Little Joe in its developmental flights.

THIOKOL's record of propulsion reliability in the spatial program is long and brilliant, reaching back to the X-17 which flew successfully in 96% of its launches, and to earlier research vehicles.

In NASA's Little Joe series, THIOKOL booster motors in various configurations have developed up to 250,000 lbs. thrust, today's ICBM class. Smaller THIOKOL rockets have been used to free escape capsule from booster.



Little Joe has carried this research and development capsule and research animals to varying altitudes to obtain engineering and medical data prior to launching man into orbit with subsequent safe recovery. The reliable THIOKOL solid rocket motors used in these missions are virtually off-the-shelf items and are available to other research groups.

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to joining Texas Instruments, Mr. Fourney was associated with Sperry Gyroscope Co.

Newman A. Hall (AF), Chairman of the Department of Mechanical Engineering at Yale University, has been chosen a Vice-President of the American Society for Engineering Education, in charge of the Society's instructional division and committee activities.

Walter M. Hartung (AF), Dean of the Academy of Aeronautics, La Guardia Airport, New York, received the degree of Doctor of Philosophy from New York University on June 8. Dr. Hartung specialized in Higher Education Administration at the School of Education. His thesis was entitled, "The Emergence of the Engineering Technician in Aviation."

Thomas T. Hinman (A), previously General Sales Manager of Lockheed Aircraft Service, Inc., has been elected Vice-President—Sales.

Richard B. Hubbard (M), formerly Vice-President and Assistant to the President, Pacific Airmotive Corp., now is Vice-President, Roylon Incorporated, Glendale, Calif.

Marvin J. Kahn (M), Director of the Plans and Programs Division, Aircraft Armaments, Inc., has been elected Vice-President—Marketing of the company.

Albert J. Kullas (M) has been appointed Engineering Technical Director for The Martin Company's portion of the Dyna-Soar Program. Mr. Kullas was formerly Manager of Technical Development.

John Laufer (M) has been appointed Chief of the Gas Dynamics Section, Physical Sciences Division, of California Institute of Technology's Jet Propulsion Lab. Dr. Laufer was formerly a Research Specialist.

Grover Loening (F) has been retained as Consultant to Curtiss-Wright Corp.

Harner Selvidge (M) has joined Meteorology Research, Inc., as Vice-President and General Manager. Dr. Selvidge was previously Western Corporate Representative for Bendix Aviation Corp.

Jack O. Nash (M) has been named Chief Engineer of Chandler Evans Corp. Prior to his promotion, Mr. Nash was Assistant Chief Engineer.

Robert V. Meghreblian (M) has been named Chief of the Physical Sciences Division at the California Institute of Technology Jet Propulsion Lab. Dr. Meghreblian was previously Chief of JPL's Physics Section.

James A. Nicholls (M), a Research Engineer in The University of Michigan Research Institute and Lecturer in Aeronautical Engineering, has been named Associate Professor of Aeronautical and Astronautical Engineering, beginning with the 1960–1961 year.

Lt. Gen. Donald L. Putt, USAF (Ret.) (F), President of United Technology Corp. and 1960 President of the IAS, was recently elected an alumnus member of the Board of Trustees of the Carnegie Institute of Technology.

G. J. Rauschenbach (M), until recently Director of Air Force Requirements for The Martin Co., Denver, has been named Manager of the company's office in Huntsville, Ala.

Arthur E. Raymond (HF), recently retired Senior Vice-President—Engineering, Douglas Aircraft Co., Inc., has joined the staff of The RAND Corp. as a special consultant.

N. C. Schnaubelt (A), formerly a Sales Representative with the Dallas office of Solar Aircraft Co., has joined the Customer Relations Dept. of Temco Aircraft's Missiles and Aircraft Division. Mr. Schnaubelt's new title is Military Liaison Engineer.

Murry Schoenberger (M), formerly with the Naval Air Test Facility, Lakehurst, N.J., is now an Aircraft Stress Analysis Engineer with the Airframe and Equipment Branch, Bureau of Flight Standards, Federal Aviation Agency.

W. H. Stinson (M) has been named Western Division Sales Manager for Cessna Aircraft Co. Mr. Stinson was formerly a Regional Sales Manager for the company.

Allen R. Stokke (M) has been appointed Manager of the Garrett Corporation's Detroit sales office. Mr. Stokke was previously assigned to the company's Dayton sales office.

Ronald S. H. Toms (AF) has joined Electro-Optical Systems, Inc., as a Senior Scientist in the Fluid Physics Division. Mr. Toms was previously Director of Wiancko Aeronautics.

Walter Tydon (AF) now is associated with Space Technology Laboratories, Inc., Los Angeles, as Assistant Program Director, Experimental Space Projects Office. He formerly was Chief Engineer of Fairchild Aircraft and Missiles Division of Fairchild Engine and Airplane Corp.

Peter P. Wegener (AF) has been appointed Professor of Mechanical Engineering at Yale University. Professor Wegener was a Section Chief at California Institute of Technology's Jet Propulsion Lab. prior to his new appointment.

Necrology

W. A. Klikoff

W. A. Klikoff (AF), a Founding Member of the Institute of the Aeronautical Sciences, died on April 3, in Los Angeles, Calif. Mr. Klikoff was Chief of the Engineering and Manufacturing Division, Los Angeles, of the Federal Aviation Agency, and Acting Chief, Flight Standards, FAA, for the Western United States.

Born in the Crimea on December 29, 1898, the son of an Admiral in the Imperial Russian Navy, he came to the United States in 1919 and became a citizen in 1926. He attended the Massachusetts Institute of Technology, receiving his B.S. in Naval Architecture in 1923. After a short period in marine work, he joined the Aircraft Development Corp. in Detroit, and contributed to the development of the metal-clad airship. Subsequently he worked with Verville Aircraft Co., Detroit Aircraft Corp., and Metalclad Airship Corp. Moving to California in 1933, he worked on the structural design of the DC-1, DC-2, DST, and DC4E, instructing part-time at the California Institute of Technology.

Joining the Civil Aeronautics Administration (now the FAA) in 1937, as a Structural Engineer in the Los Angeles office, he served later in positions throughout the country before returning to California. He played a leading role in the airworthiness approval of most U.S. transports certificated during the last 20 years.

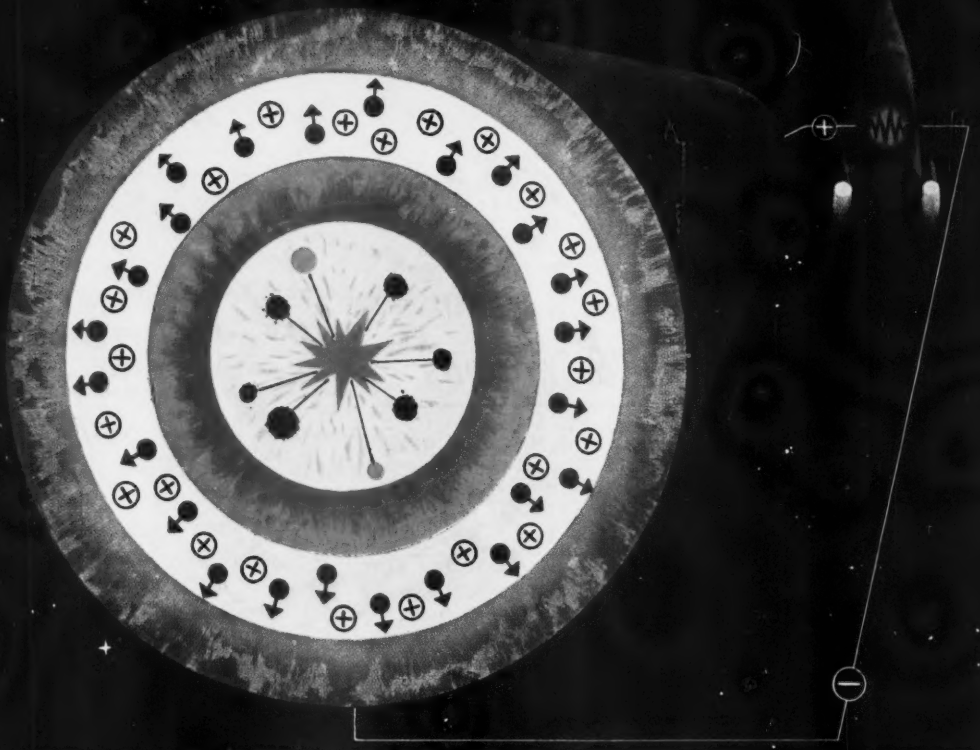
Lt. Comdr. Delbert L. Nall (A)
March 3, 1960, Oceana, Va.

Arthur C. North (M)
January 7, 1960, Beverly Hills, Calif.

Capt. Howard T. Orville, USN (Ret.) (M)
May 24, 1960, Baltimore, Md.

H. C. Risner (A)
March, 1960, Long Beach, Calif.

ANOTHER ASPECT
OF THE
MARQUARDT MISSION



PLASMA THERMIONICS FOR SPACE POWER

The most ideal electric power sources yet devised for the operation of space vehicles are the nuclear and solar heated plasma thermionic systems which are in work in ASTRO, Marquardt's division for research into the space age.

Planned to replace the heavier, and more complex turbo-electric systems, ASTRO's designs employ the plasma diode thermionic converter to transform nuclear or solar energy into electric power without the use of moving parts.

The conversion is extremely simple. Nuclear or solar energy heats a refractory metal plate (a cathode) to a temperature far beyond the melting point of steel. This causes electrons to be boiled off and collected by a cooler plate—thereby creating electrical energy. Cesium plasma is contained between the two plates which form the cell. The positive cesium ions help the electrons along during their movement from the heated to the cooled elements of the cell, thus, increasing the amount of current that can be made to flow.

ASTRO's plasma thermionic power studies typify but one aspect of The Marquardt Mission.

Creative engineers and scientists are needed.

ASTRO DIVISION

THE Marquardt CORPORATION

CORPORATE OFFICES: VAN NUYS, CALIFORNIA

◆ ASTRO ◆ COOPER DEVELOPMENT DIVISION ◆ OGDEN DIVISION ◆ POMONA DIVISION ◆ POWER SYSTEMS GROUP

IAS News — Corporate Member News

• **American Bosch Arma Corp.** has reorganized its commercial and military sales into two separate activities. Commercial sales are under a new division, the American Bosch Sales Division, while military sales will be under the direction of Vice-President W. Paul Smith. Other changes include the consolidation of the Chicago Division operations with the Tele-Dynamics Division in Philadelphia and the Arma Division in Garden City.

• **Avien, Inc.,** has announced the purchase of Colvin Laboratories, Inc., and Pressure Elements, Inc. Colvin manufactures electromechanical instrumentation for automated industrial applications, missiles, aircraft, and undersea devices. Pressure Elements produces pressure capsules for a wide variety of transducers. Both firms will continue under their present managements.

• **Bendix Aviation Corp.** has dropped "Aviation" from its name, changing its official designation to The Bendix Corporation.

• **General Precision Equipment Corp.** has announced plans to combine operations of two of its subsidiaries, GPE Controls, Inc., and General Precision, Inc.

• **Thiokel Chemical Corp.** has established a Nuclear Unit at Parsipanny-Troy Hills, N.J., for research and study of nuclear propulsion for space travel.

• **Thompson Ramo Wooldridge Inc.** dedicated its new Colwell Engineering Center in Cleveland on June 15. The center was named in honor of Arch T. Colwell, Vice-President—Engineering, Research, and Development.

IAS News — IAS Sections

Section Officers Elected

A number of the Institute's Sections have elected officers for the 1960–1961 season. Results which have been received to date are listed below.

Baltimore Section—New officers are Lester K. Fero, Chairman; Ronald G. Clanton, Vice-Chairman; James K. Marstiller, Secretary; and Lee G. Wentling, Jr., Treasurer. Elected to the Advisory Board are William A. Bortner, Marvin J. Kahn, James H. Bennett, and Dr. Andrew McCourt.

Boston Section—New officers are J. J. Kirby, Chairman; J. R. Baron, Vice-Chairman; J. A. Gautraud, Secretary; and W. B. Bryant, Treasurer.

Cleveland-Akron Section—New officers are C. J. Pennig, Chairman; T. R. Thoren, Vice-Chairman, Cleveland; R. Ross, Vice-Chairman, Akron; W. T. Olson, Secretary; and R. K. Chamberlain, Treasurer. Section Representative to the Area Vice-President's Advisory Committee is J. C. Evvard. Elected to the Advisory Board are Adm. C. M. Bolster, R. E. Bolz, J. C. Evvard, B. T. Lundin, E. J. Manganiello, C. Noon, P. O. Pfeiffer, and J. O. Gibson.

Hampton Roads Section—New officers are John M. Eggleston, Chairman; Laurence K. Loftin, Jr., Vice-Chairman; William C. Hayes, Jr., Secretary; and Donald D. Davis, Jr., Treasurer. Elected to the Advisory Board are Hartley A. Soule, Eugene C. Draley, James G. McHugh, Charles J. Donlan, and Richard E. Kuhn.

Indianapolis Section—New officers are Harvey W. Welsh, Chairman; R. J. H. Bollard, Jr., Vice-Chairman; Curtis Walker, Secretary; and Charles L. Dittoe, Treasurer. Elected to the Board of Directors are H. Weir Cook, Jr., William G. Emmick, James B. Keough, and Paul S. Lykoudis.

Kansas City Section—New officers are Don Crowley, Chairman; Mason Thompson, Vice-Chairman; Floyd Wohlrab, Secretary; and Mark Baldwin, Treasurer. The new Advisory Board consists of Professor Andes, Sam Higginbottom, Homer Mouden, William Numbers, Yudell Luke, and John A. Carran.

Rocky Mountain Section—New officers are Laurence R. Soderberg, Chairman; George Teeter, Vice-Chairman; Richard H. Ball, Secretary; and Paul A. Lord, Treasurer.

Washington Section—New officers are Ed Virgin, Chairman; Harold Andrews, Vice-Chairman; Eugene Norris, Secretary; and Mason T. Charak, Treasurer.

Wichita Section—New officers are Robert K. Wattson, Jr., Chairman; Chester A. Rembleski, Vice-Chairman; Charles E. Jackson, Secretary; and Bert B. Overfield, Jr., Treasurer. Advisory Board members are Milford F. Vanik, Thomas B. Salter, James Lew, and Glen S. McCormick.

Jacqueline Cochran, *standing*, addresses May 18 Columbus Section dinner meeting. Listening with obvious enjoyment are, *seated from left*, Section Chairman R. W. Anderson; J. W. Bush, Director of Commerce for the State of Ohio; Mrs. Anderson; and W. H. Yahn, President and General Manager, Columbus Division of North American Aviation, Inc.

Antelope Valley Section

SAC . . . Today and Tomorrow

"Manned aircraft will be required for the next 15 years." "We need the B-70 and we're going to get it—and we'll get as many as we need." These statements were made by **Col. Guy M. Townsend, USAF,** Chief of the Requirements Division, Directorate of Operations, SAC, at an unclassified briefing before the May 25 meeting.

Colonel Townsend stated that ballistic missiles are phasing into SAC but that the "big stick" behind the soft-spoken policies of the United States is still the manned bomber. Inexpensive stretch out of the operational usefulness of the B-47's and B-52's is being obtained by several devices, such as the GAM-72 Quail, the GAM-77 Hound Dog, and the GAM-87A Skybolt. The McDonnell Quail is an air-launched diversionary missile designed to protect the manned bomber by confusing the enemy radar. The North American Hound Dog is a penetration missile which permits the manned bomber to use the "stand-off" bombing technique. It is especially useful against heavily defended targets. Both the Quail and the Hound Dog are jet-propelled, sonic-speed weapons.

The hope of SAC for the immediate future is the Douglas Skybolt air-launched ballistic missile, or ALBM. The Quail and Hound Dog make the bombing task a little easier; the Skybolt eliminates it. With the Skybolt, the bomber can launch an attack from a distance of 1,000 miles from the target.

Colonel Townsend felt that it will be impossible to use manned bombers until 1975 unless SAC gets the North American B-70 Valkyrie Mach 3 manned bomber—and SAC sees a definite requirement for the bomber until 1975.

JAMES A. MARTIN, *Publicity Chairman*

Columbus Section

Jacqueline Cochran Addresses Annual Distaff Dinner

Jacqueline Cochran, world famous aviatrix, was the honored guest and speaker at

(*Continued on page 48*)

EDITORIAL

Institute of the Aerospace Sciences . . .

IAS Council recommends name change to membership

To make its official title consistent with its professional objectives and activities, the Council of the Institute of the Aeronautical Sciences, meeting in the Ambassador Hotel in Los Angeles, June 29, 1960, voted unanimously to submit a name change to the IAS membership for approval. It recommended that the now universally accepted word "Aerospace" be substituted for the word "Aeronautical" in the title by which the Institute has been known since 1932. If the membership concurs, the organization will become officially the "*Institute of the Aerospace Sciences.*" The long-established and familiar "IAS" designation will remain unchanged.

This history-making session of the Council was attended by members from all over the United States. President Donald L. Putt presided. Present also were many Past Presidents of the Institute, including James H. Doolittle, Hugh L. Dryden, Arthur E. Raymond, Hall L. Hibbard, Clark B. Millikan, John K. Northrop, and L. B. Richardson. The Council action was the result of a resolution proposed by IAS Vice-President Harold Luskin on behalf of the Combined IAS Regional Advisory Committees which had convened the preceding day.

The IAS has always dealt with scientific and technical subjects concerning flight at all speeds and at all altitudes "from Zero to Infinity." Long before the terms *missile* and *spacecraft* became subjects of popular interest, IAS meetings and publications included many papers and discussions on such fundamental problems as Hypersonics, Rarefied Gas Dynamics, Thermal Effects, Thin-Walled Cylindrical Structures, etc., etc.—subjects on which our present space technology is based. Dr. Theodore von Kármán, Dr. Hugh Dryden, Dr. Clark Millikan, and many others made early and important contributions in such areas through the IAS. The IAS Roster, which is included as a part of this issue, contains the names of the outstanding scientists and engineers who are concerned with aerospace development.

Actually, in the titles of its publications, the IAS has used the combination "Aero" and "Space" since May, 1958, when the title "Aero/Space Engineering" first appeared on its monthly engineering magazine. Two months later (July, 1958) the IAS Journal became "The Journal of the Aero/Space Sciences." It is believed that this was the first published usage of the related words to define the total area of the flight sciences.

For IAS purposes, the compound term is important. In addition to the technical aspects of space travel, many IAS members are vitally involved in problems concerning the advancement of travel and national defense within the Earth's atmosphere. There are many problems yet to be solved in such areas, both in military and in commercial fields. These matters are of great concern to the IAS as the professional society in the aerospace field, as is well demonstrated by great interest in the San Diego meeting (Aug. 1–3).

The Council's decision must be referred to the IAS membership for ratification. A copy of this editorial and a returnable ballot have already been sent out to the voting members. It is urged that the proposal be acted upon promptly so that the necessary legal steps remaining can be taken to carry out your Council's recommendation. —SPJ

EDITOR'S NOTE: *As this issue goes to press, of the approximately 5,000 ballots already received at IAS headquarters, the voting is roughly 9 to 1 in favor of the above change.*

"Is there a future for the air-breathing aircraft engine, or is it really doomed to obsolescence so short a time after making its appearance?"

Application of Air-Breathing Jet Engines to High Mach Number Vehicles

M. Arens, MIAS, *Israel Institute of Technology*

THE FIRST TURBOJET ENGINE was developed 20 years ago at a time when many considered it to be of little practical utility. Since then, the air-breathing jet engine has been developed at a lightning pace, until today turboprops, turbofans, and turbojets are squeezing the reciprocating engine out of all but a few limited applications. And yet there is already talk of a similar fate in store for the air-breathing jet engine. The number of engines under development has decreased drastically during the past 2 years, while increasing emphasis is being put on rocket engines. Many consider the B-70 strategic bomber the last of the long line of high-speed aircraft to be powered by air-breathing engines.

Is there a future for the air-breathing aircraft engine, or is it really doomed to obsolescence so short a time after making its appearance? In an attempt to answer this question, the air-breathing engine must be compared to its competitor, the rocket engine.

Although the basic thermodynamic cycle of all rocket engines is the same, there are a number of variants of the air-breathing jet-engine cycle—i.e., turboprop, turbofan, turbojet, ram-jet—as well as afterburning versions of some of these engines. Since, however, all air-breathing engines have a number of characteristics in common, certain conclusions may be drawn by comparing the air-breathing engine family as a whole with the rocket engine.

Jets Versus Rockets

Even if we neglect production, maintenance, and cost considerations, there is no single index of merit for comparing aircraft engines. The three primary parameters of interest are fuel consumption, weight, and speed.

Symbols

c_p	= specific heat capacity at constant pressure, B.t.u./lb.-°F.
c_v	= nozzle velocity coefficient
I	= specific impulse, sec.
F	= engine thrust, lbs.
m	= engine mass flow, slugs/sec.
sfc	= specific fuel consumption, hours^{-1}
T_t	= nozzle inlet total temperature, °F.
t	= time of flight, hours
p_0	= ambient pressure, lbs./in.^{2}
p_t	= nozzle inlet total pressure, lbs./in.^{2}
V	= flight velocity, miles/hour
W_e	= engine weight, lbs.
W_{f+e}	= weight of engine and fuel, lbs.
γ	= ratio of specific heat capacities
η_c	= compressor efficiency
η_t	= turbine efficiency

The first two are intimately related to the weight of the aircraft; the smaller the weight of fuel and engine to be carried, the smaller the aircraft take-off weight to accomplish the desired mission. The third criterion, speed, is an inherent part of most military and astronautic mission specifications, while its relative importance in the field of commercial aviation may be judged by the tremendous passenger appeal of the newly introduced jet aircraft.

Fuel Consumption

Although jet-engine fuel consumption is generally expressed as sfc (lbs./hour/lb.), while rocket fuel consumption is stated in terms of specific impulse (sec.), the two are related by the simple equation $sfc = 3{,}600/I$.

Mr. Arens is a visiting Senior Lecturer in the Department of Aeronautical Engineering at the srael Institute of Technology. He received an S.B. in mechanical engineering from M.I.T. in 1947, and an M.S. in jet propulsion from the California Institute of Technology in 1953. From 1954 to 1958 he worked for the Wright Aeronautical Division of the Curtiss-Wright Corp. as Project Engineer on turbojet and turbo-ram-jet design and development.

It takes a pretty big piece of paper to plot the fuel consumption of both types of engines on the same ordinate. As can be seen from Fig. 1, the economy of the air-breathing engine is an order of magnitude better than that of the rocket. Unfortunately, we are not in a position to extend the comparison to higher speeds simply because air-breathing engines have not yet flown at those speeds. Whether they will and what their fuel consumption will be has a strong bearing on the comparison we are trying to make. But we shall return to this question later.

Engine Weight

The superior economy of the jet engine is, of course, due to the fact that it, unlike the rocket, does not have to carry its oxidizer, but rather scoops it out of the atmosphere. Unfortunately, there is a penalty in engine weight to be paid for this advantage. Whereas the rocket engine maintains the combustion chamber pressure required to obtain thrust by pressurizing the fuel and oxidizer in the dense liquid or solid state, the air-breathing engine must compress the incoming air-stream. This accounts for the following characteristics of air-breathing jet engines:

(1) The jet-engine pressure level depends directly on the ambient pressure. Therefore, at any given flight speed, there is a rapid decrease in thrust with altitude.

(2) At low flight speeds, almost all of the compression must be obtained by heavy turbine-driven compressors. With increasing speeds, a progressively larger share of the compression can be obtained, by virtue of the flight velocity, in the inlet at little expense in engine weight. At supersonic speeds, this compression is much larger than that obtainable in the compressor. Engine thrust, as well as thrust-to-weight ratio, therefore increases with flight speed.

(3) The in-flight admission of air into the engine results in a "ram drag" penalty. Therefore, an air-breathing jet engine operating at the same combustion pressure and temperature as a rocket engine will produce less thrust than the rocket.

On the other hand, the rocket engine's thrust and specific weight are almost invariant with speed and altitude. Fig. 2 compares the specific weight (pounds of weight per pound of thrust) of jet and rocket engines. It can be seen that, even though the jet engine may at times be competitive with the rocket engine in specific weight, this occurs in a region which is generally of little interest (high speed at low altitude). Where it counts (sea-level take-off and high speed at high altitude), the rocket engine is much superior.

The combined importance of fuel economy and engine weight must be evaluated for each mission of interest by computing the sum of fuel expenditure and engine weight. The total weight of fuel and engine is given by

$$W_{f+e} = \int_0^t F(sfc)dt + \left(\frac{W_e}{F_{crit}}\right)F_{crit}$$

where F_{crit} is the critical thrust requirement of the mission—i.e., that condition for which the engine must be sized. It is important to note that the dependence of thrust on speed and altitude determines the time required to traverse a given trajectory and, therefore, strongly influences the value of the integral.

For missions in which the thrust and fuel consumption remain constant, the ratio of fuel plus engine weight to thrust is given by

$$W_{f+e}/F = (sfc)t + (W_e/F)$$

This relation is approximately applicable to the cruising flight of aircraft powered by either jet or rocket engines, and is plotted in Fig. 3 for both types of engines. Although most missions of interest also include climb and acceleration legs, Fig. 3, nevertheless, demonstrates the salient parameters involved in the comparison between the two engine types. It shows that the cruising time required for the jet engine's superior fuel consumption to balance its higher weight increases with cruising altitude, but is still relatively short even at 100,000 ft.

If the cruising time is expressed as range divided by cruising velocity, we can compare power plants operating at different speeds but covering the same range. The measure of the fuel consumption during the flight is sfc/V lbs. of fuel per lb. thrust per mile.

Since the best air-breathing engine fuel consumption is some fifteen times better than that of the best rocket, it is the superior cruise power plant even when compared to a rocket operating at a much higher speed.

Flight Speed

In recent years, however, increasing attention has been focused on missions in which the aircraft is powered during only a small fraction of its flight trajectory. In such missions, the vehicle covers the desired range by attaining a sufficient level of kinetic energy to coast or glide to its destination. Examples of vehicles using such trajectories are ballistic missiles, hypersonic gliders, sounding rockets, and satellite launchers. The function of the power plant in these missions is to accelerate the vehicle to the required maximum velocity rather than balance the aerodynamic drag in cruising flight.

How does the air-breathing jet engine compare to the rocket in this type of application? For many missions of interest, the final velocity required is above 15,000 ft./sec., and air-breathing engines are not capable of operating at such speeds. However, one

should inquire into the possibility of using air-breathing engines for that part of the acceleration in which they operate efficiently.

Although the advisability of using air-breathing booster engines to accelerate the vehicle to the engine's speed limit must be determined by an analysis of the mission in question, three general requirements are obvious on the basis of what has been said up to this point:

(1) Because of the rapid increase of air-breathing engine specific weight with altitude, the best accelerating trajectory for a vehicle powered by air-breathing engines must be such as to maintain maximum pressure at the engine inlet face. It should therefore be much flatter than that of a rocket-powered vehicle. Such a trajectory will generally require the use of aerodynamic lift to support the vehicle.

(2) Whereas current air-breathing engines are required to operate efficiently in a relatively narrow speed range, for booster applications they will have to operate over a much wider range.

(3) The length of time the engine s required to operate is decisive in determining whether the air-breathing engine is superior to the rocket engine. Therefore, the advantage of using air-breathing engines hinges strongly on the velocity increment that can be supplied by it—on its maximum speed limit.

Air-Breathing Engines for Wide Speed Range

The flexibility of the air-breathing engine cycle is demonstrated by the many different types of air-breathing jet engines in current use. Fig. 4 shows the range of efficient operation of these engines. Unfortunately, the efficiency of each engine type decreases quite rapidly outside a limited range of operation. The

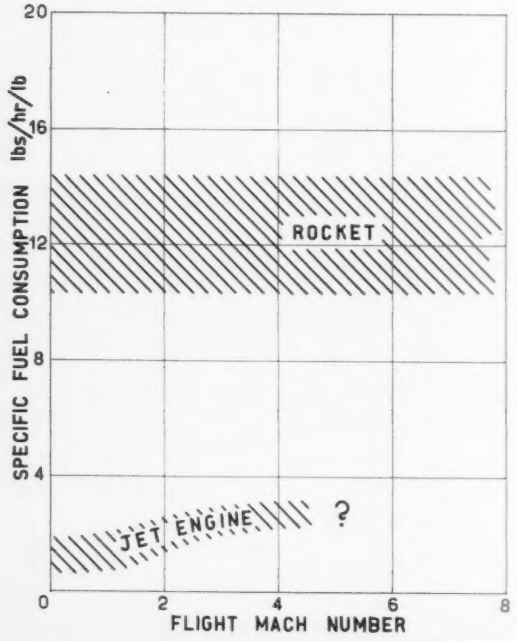


Fig. 1. Specific fuel consumption of jet and rocket engines.

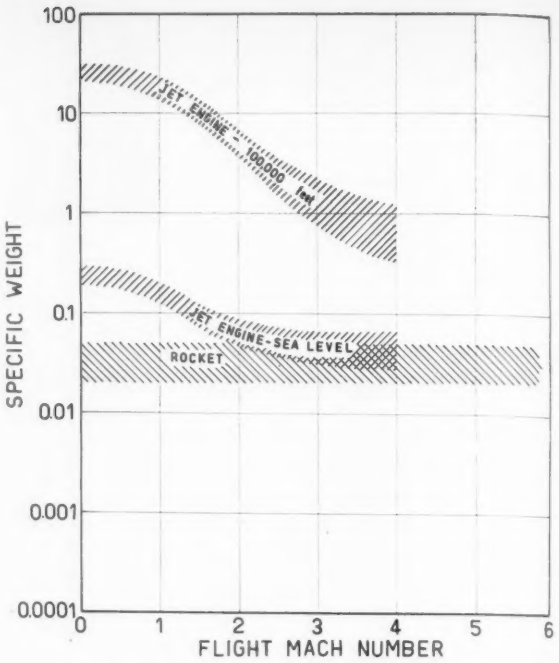


Fig. 2. Specific weight of jet and rocket engines.

turbojet engine which has a relatively wide operating speed range, particularly when fitted with an afterburner, is very sensitive to the cycle parameters. The optimum compression ratios of afterburning turbojet engines as a function of speed and turbine inlet temperature are shown in Fig. 5. Whereas high compression ratios are desirable for lower speed flight, the optimum compression ratio decreases rapidly with flight speed. Moreover, within the limits of currently attainable turbine temperatures, no mechanical compression—i.e., ram-jet operation—is best at speeds beyond Mach 4.[1] It should be noted, however, that the operating compression ratio of a turbojet running at constant shaft speed decreases with flight speed because of the effect of inlet temperature on the "corrected speed" of the compressor. It is therefore possible to obtain near-optimum compression ratios over a relatively wide speed range. But, if the engine is designed to provide high compression ratios at low speed, its specific weight at high speed will be relatively poor because of the weight of the compressor-turbine system. The ram-jet, on the other hand, while providing good economy and low specific weight at high speeds, has an infinite specific weight at take-off—it can provide no static thrust.

What is the optimum configuration for an air-breathing engine required to accelerate a vehicle over a a wide speed range? Although there may be no single answer to this question at this time, a number of trends are indicated.

Afterburning

The simplest way to improve the specific weight of an air-breathing engine radically is to install an after-

burner. Because of current limitations on allowable turbine temperatures, the "dry" thrust of the engine can be greatly augmented by the addition of heat downstream of the turbine. Since the afterburner contains no rotating components, it is relatively light. The increase in engine weight is considerably smaller than the increase in engine thrust, resulting in a net gain in specific weight.

The thrust augmentation attainable by afterburning increases rapidly with flight speed. The maximum possible augmentation attainable by stoichiometric burning is shown in Fig. 6. Needless to say, the primary difficulties in the efficient operation of a stoichiometric afterburner at supersonic speeds concern adequate cooling of the structural components of the burner and exhaust nozzle.

High Turbine Inlet Temperature

The large improvement in engine specific weight obtainable by afterburning is a result of the fact that current turbine temperature limitations restrict main combustor operation to relatively lean fuel-air ratios. If the material and cooling problems associated with running turbines at temperatures beyond 2,500°F. can be overcome, it will be possible to design high-speed nonafterburning turbojets having better fuel consumption and lower specific weight than current afterburning engines.

Ram-Jet

The ram-jet, because of its light weight and superior economy at high flight speeds, is the ideal air-breathing power plant for hypersonic speeds. Its poor performance at low speeds and zero thrust level on take-off constitute its signal disadvantage. A turbo-ram-jet combination power plant, capable of switching from the turbojet-afterburning to the ram-jet mode of operation, has the potential of constituting an efficient air-breathing power plant giving good performance over a wide speed range.[2] Successful integration of some of the common engine components, such as the inlet, afterburner, and exhaust nozzle, should provide this type of power plant with reasonably good specific weight characteristics.

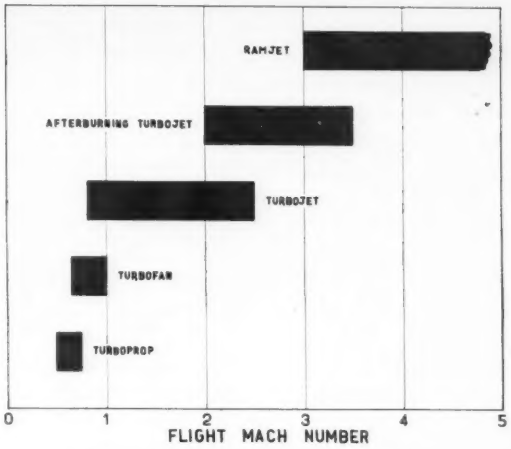


Fig. 4. Efficient operating range of jet engines.

Auxiliary Rockets

Because of the sensitivity of air-breathing engine thrust to altitude, and because of their own poor specific weight characteristics on take-off, auxiliary rockets for take-off and/or trajectory control in the speed-altitude plane could considerably increase their attractiveness as accelerating power plants.

Vehicle Staging

Since air-breathing power plants, as opposed to rockets, have a relatively narrow speed range of efficient operation, they are particularly suited for use in staged vehicles. Efficient operation of the power plant can be assured because each stage of the vehicle traverses only a portion of the total ve ocity increment. A three-stage vehicle might contain a rocket-booster stage, a ram-jet-powered second stage, and a rocket-powered third stage.

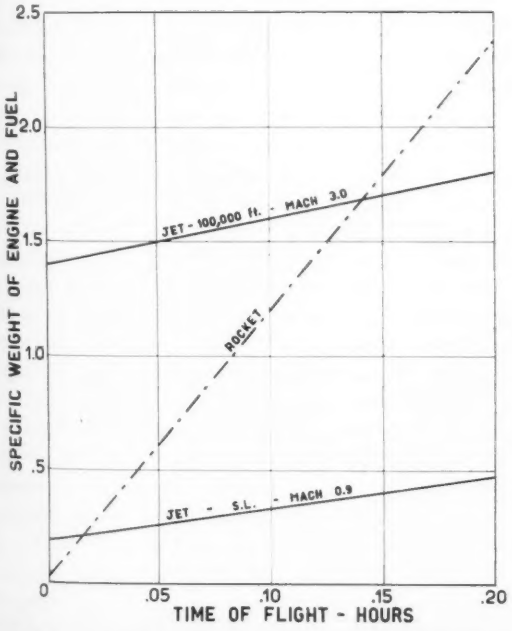


Fig. 3. Specific engine plus fuel weight of jet and rocket engines.

Increasing the Speed Limit of Air-Breathing Engines

The ultimate success of air-breathing engines as accelerating power plants hinges on increasing their speed limit. Even though the ideal high-speed air-breathing engine—the ram-jet—dispenses with the weight and complexity of the gas generator, the remaining components—the inlet, combustion chamber, and exhaust nozzle—become considerably more complex with increasing flight speed.

The outstanding effect of speed on air-breathing engine performance is the large pressure ratio available across the engine as the result of ram compression.

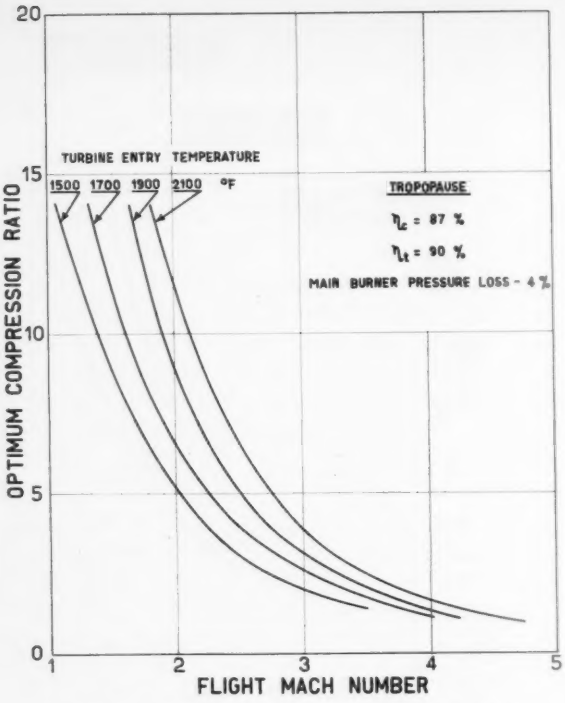


Fig. 5. Optimum compression ratio for afterburning turbojets.

From an examination of the equation for engine thrust

$$F = m\left\{c_v\sqrt{2c_pT_t\left[1-\left(\frac{p_0}{p_t}\right)^{(\gamma-1)/\gamma}\right]} - V\right\}$$

the following characteristics of high-speed air-breathing engines become apparent:

(1) Since large nozzle pressure ratios p_t/p_0 are available because of ram compression, the engine thrust per pound of airflow and the specific fuel consumption are not very sensitive to pressure losses within the engine.

(2) With increasing flight speed, the importance of the nozzle velocity coefficient increases radically. Whereas on take-off a one per cent change in C_v leads to a one per cent change in thrust and fuel consumption, at high speed the effect becomes greatly magnified.

For the engine structure, the high inlet air temperatures and associated cooling problems are of paramount importance.

Some of the problems associated with the components of high-speed ram-jet engines are outlined below.

The Inlet

The primary problem of high-speed engine inlets is the large inlet capture area required to swallow the engine airflow. Fig. 7 shows the ratio of inlet capture area to combustion chamber area for an inlet of 100 per cent efficiency, assuming a Mach number of 0.2 at the entrance to the combustion chamber. Decreasing inlet efficiency decreases the required capture area in direct proportion since the inlet is allowed to swallow less air. This loss in airflow is, of course, accompanied by an equal loss in thrust. Even if reasonable recoveries are assumed, the capture areas required at high speeds are extremely large.

One obvious solution to this problem is to compress the air upstream of the engine inlet face either on suitably located precompression surfaces or on the structural components of the aircraft, such as the wings or fuselage. The capture area for a perfect inlet using a 10° precompression wedge ahead of the inlet is also shown in Fig. 7, indicating the large reduction in capture area attainable by precompression.

It should be noted that considerable variation of the inlet geometry is necessary if optimum efficiency and airflow are to be obtained over a range of flight speeds.

The Exhaust Nozzle

The essential difference between exhaust nozzles for high-speed engines and those for engines operating at lower speeds is the large pressure ratio available across the nozzle at hypersonic speeds. Fig. 8 shows the ram pressure ratio as a function of speed. Even though not all of the ram pressure ratio acts across the nozzle, because of the inlet recovery and combustion chamber pressure loss, hypersonic engines will have to contend with nozzle pressure ratios above 100. The required ratio of nozzle exit area to nozzle throat area for full expansion is shown in Fig. 9. Any deviation from full expansion results in a decrease of the nozzle velocity coefficient and a consequent penalty in engine performance. Fig. 9 also shows the nozzle area ratio required if a one per cent penalty in velocity coefficient is allowed. As can be seen, the exit area can be considerably reduced without unduly penalizing nozzle performance. However, the large effect of nozzle performance on engine thrust and economy must be borne in mind.

In the nozzle, as in the inlet, some of the difficulties associated with the large exit area requirement may be alleviated by expanding the engine flow on aircraft surfaces.

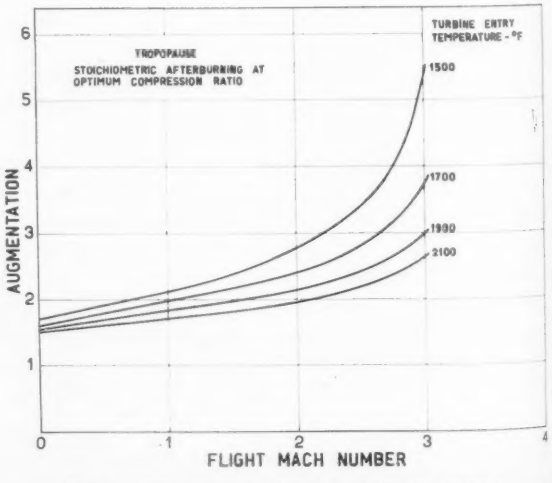


Fig. 6. Maximum augmentation for afterburning turbojets.

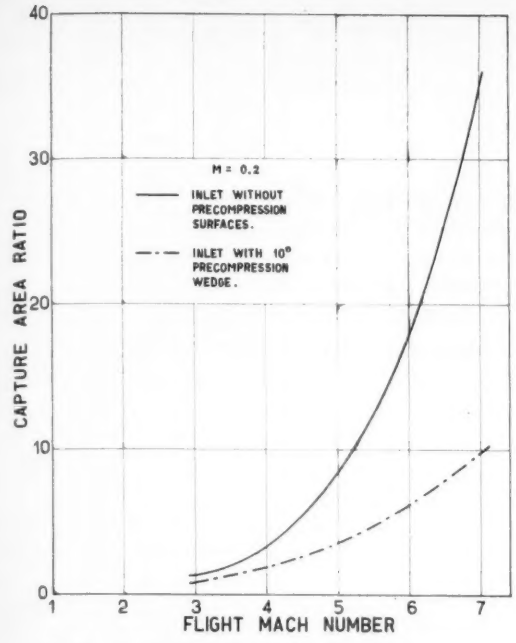


Fig. 7. Inlet capture area ratio for hypersonic jet engine.

The problem of varying the exhaust nozzle geometry to obtain optimum performance over a range of speeds is even more difficult than in the case of the inlet because of the higher temperatures prevailing in the nozzle.

The Combustion Chamber

The performance of air-breathing engines at hypersonic speeds hinges largely on the performance of the combustion chamber. The extreme engine inlet temperatures, associated with hypersonic flight, limit the possibility of converting chemical fuel energy to thermal energy in the gas stream. This limit is set by dissociation and ionization effects in the fuel-air mixture at high temperatures. As a result, progressively less of the fuel energy is available for raising the thermal energy of the gas stream. Unless the energy expended for dissociation and ionization can be reconverted to thermal energy by reassociation reactions as the gas cools in the exhaust nozzle, it makes no contribution to the propulsive thrust of the engine. Although the degree of reassociation to be expected in high-temperature fuel-air mixtures on expansion in the nozzle is not completely determinate at this time, there seems little doubt that high-temperature dissociation and ionization will significantly affect air-breathing engine performance at hypersonic speeds.

Since the problem arises as a result of the deceleration of the entering air stream and the associated temperature rise, the obvious solution is to attempt to burn the incoming air without significantly decelerating it. Thus the combustor inlet temperature can be maintained near the ambient condition. Also, stream temperatures and pressures through most of the engine will be considerably lower than in a conventional ramjet operating at the same speed, easing the problem of cooling the engine structure. Since mean flow velocities throughout such an engine are supersonic, the geometry of the inlet and exhaust nozzle can be greatly simplified. Recent experimental work[3–5] has indicated the possibility of burning in supersonic streams by stabilized detonation waves. Should supersonic combustion be established as practicable, we may anticipate a significant increase in the speed limit of ram-jet engines.

Conclusions

The air-breathing engine, because of its superior fuel consumption, will continue as the optimum power plant for cruising vehicles. For accelerating trajectories, such as satellite launchers and sounding rockets, the air-breathing engine is currently penalized by its poor specific weight characteristics and low speed limit.

(*Continued on page 46*)

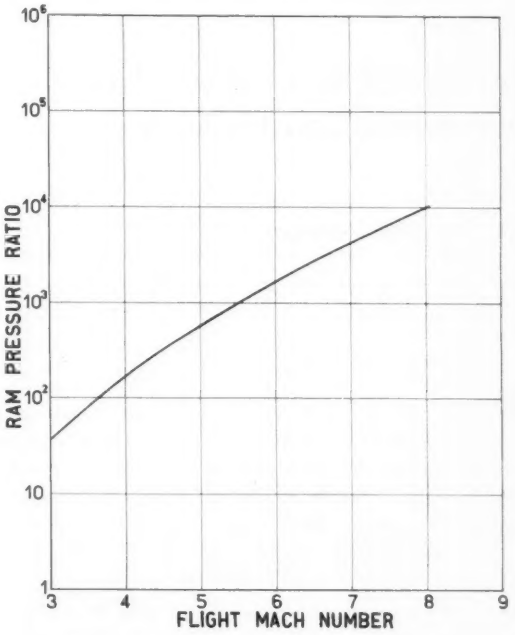


Fig. 8. Ram pressure ratio at hypersonic speeds.

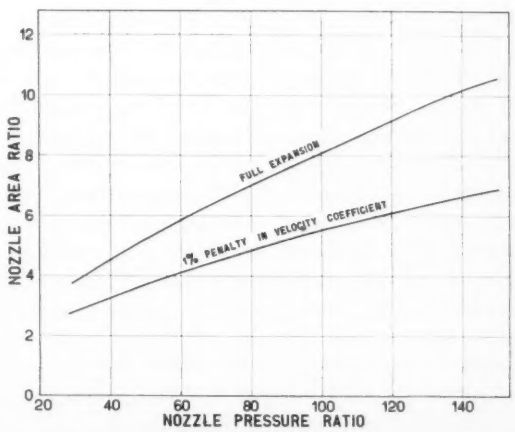


Fig. 9. Nozzle area ratio for hypersonic jet engine.

In Part I, various conventional types of cylindrical construction are compared for reliability and efficiency under several types of loading. The growth and nature of fatigue failures are discussed and correlated to hoop stress and stiffening ratio when using honeycomb as a core. Improved results are obtained with honeycomb construction in structures exposed to vibration and shock.

In Part II, to be published in September, data will be presented to illustrate the importance of uniform mechanical properties in the core by use of normal expanded and overexpanded core construction.

Sandwich Cylinders

Part I—State of the Art and Advantages of Sandwich Construction

M. I. Kazimi, ***Hexcel Products Inc.***

One of the major problems in design of aircraft or space vehicles is to produce a cylinder that will support the weight and acceleration forces of the structure and equipment attached to it, as well as the shear and bending moments caused by control forces during flight, atmospheric gusts, and wind shear. The successful cylinder must meet all the above requirements and, in addition, be safe, light, and low in cost.

Flight-condition loadings or atmospheric gusts and wind shears are comprised of various combinations of major forces such as axial compression, external or internal pressures, torsion, bending moment, and sonic cycling. The cylindrical structure (or its components) that is the most efficient when acted on by such forces will also be the most efficient under operational conditions. For this reason, discussion will be limited to the study of each of the above loading components individually to determine the efficiency, reliability, and safety of a cylindrical design, but without studying their nature in operational conditions.

The intent of this study is to identify some of the advantages obtained by the use of sandwich structures and to suggest new fields in which heretofore unattainable designs can become reality through a new application of a relatively new material. The material and designing with it is complex, but, without it, some of the problems may never have a solution.

Reliability

Designers of cylindrical structures are generally grouped into two schools of thought. The first (and probably the majority) is engrossed in designing unstiffened structures. The second is directing its attention to stiffened cylindrical structures, and it is felt that this group is on the right course.

A pressurized unstiffened structure could reasonably sustain loading of various types, inasmuch as pressurization is a great help in achieving certain goals. However, if the pressure dropped below a value necessary to carry, for example, the axial load, the cylinder would collapse and the structure would probably be damaged beyond repair. Pressurization will also prevent failure for very large bending moments, but the loss of pressure would cause loss of the vehicle, which could be catastrophic.

Harris, Suer, *et al.*, presented an interesting compilation of available test data on compressive buckling of unstiffened circular cylinders with and without internal pressure.[1] Certain curves were recommended for design. Unfortunately, the inclusion of all test data pres-

Symbols

$A_{r_{red.}}$ = reduced cross-sectional area of ring, sq.in.
d = density of material, lbs./cu.in.
l = ring spacing, in.
N_{x_0} = allowable compressive load per inch in longitudinal direction when only that load is acting, kips/in.
p = internal pressure, ksig
R or r = radius of cylinder or shell, in.
t_s = thickness of skin in pure shell, waffle-like plate, or skin stringer plate; thickness of face material in sandwich-type plate, in.
$\bar{t}$ = cross-sectional area of shell per inch of circumference expressed as an equivalent thickness, in.
σ_{cy} = compressive-yield stress of material defined by 0.2 per cent offset method ksi
σ_{hoop} = nominal hoop tensile stress in skin, pr/t_s, ksi
$d\bar{t}/R$ = weight of cylinder, being considered, in pounds per square inch of surface per inch of radius
N_{x_0}/R = structural index for bending loads, ksi
$N_{x_{y_0}}/R$ = structural index for shear loads, ksi

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ently available lowers the previously proposed design curves significantly, even for pressurized cylinders.

The pressurized cylinder is much more efficient than the unpressurized cylinder. However, in many practical applications, the unpressurized cylinders are subject to ground handling loads, intense acoustical loads, or vibration, etc. This may require a more rugged structural design, with consequent weight penalty.

It is known that strength predictions for stiffened cylinders are usually much more reliable than those for unstiffened cylinders and that the strength-weight ratio of efficiently stiffened shells exceeds that of unstiffened shells for many types of loading. It is believed, therefore, that weight-saving is possible in many practical cases if stiffened cylinders are used in place of unstiffened, although at an increase in cost and complexity of fabrication.

It is the opinion of Klein and others that more emphasis should be placed on the development and strength prediction of stiffened cylinders.[2]

Efficiency

In following the theory that stiffened cylinders could be more reliable than unstiffened cylinders, it is worth while to divert attention to the efficiency of the various types of stiffened structures and to the possibility of designing an efficient stiffened cylindrical structure.

Certainly the best design would load the cylindrical structure so that every element of the shell would be operating above the yield strength of the shell material before initiating instability and failure. This could be restated to say that, in the best design, the structure would be worked so that the energy in the cylindrical shell would be distributed in such a manner that the rate of its dissipation per unit volume of the surface material of the shell would be constant.[3]

Fig. 1 supplies a comparison between various types of stiffened cylinders from a weight-strength consideration. Values of $d\bar{t}/R$ (which measure the weight of the cylinder considered in pounds per square inch of surface per inch of radius) are plotted against the structural index N_{x_0}/R for bending loads. A detailed study of the various types of stiffeners and the plots of efficiency are covered in reference 6.

Fig. 1 indicates that waffle-like shells and longitudinally stiffened shells are nearly equivalent, from a weight and strength standpoint, for the range of loading intensities (N_{x_0}/R) considered. The pure shell is considerably heavier and the sandwich shell considerably lighter than any of the other constructions studied. The comparison indicates that sandwich construction has a decided weight advantage over other types under the action of bending loads.

Figs. 2 and 3 supply comparison plots of weight-strength of sandwich shells vs. solid shells subjected to shear stresses. The shells of Fig. 2 are made from 7075-T6 aluminum alloy and those of Fig. 3 from AZ31 A-H24.

Increasing the thickness of thin sandwich shells effects substantial increases in the moment of inertia of the section and therefore in the load the shell will carry before buckling. The increase in weight is, by comparison, small. As the sandwich is made thicker (moving to the right on one of the curves), more and more load is carried by the sandwich before buckling. Eventually, in this process, it is possible for the stress in the sandwich facings to exceed the elastic limit of the material.

Fig. 4 supplies a weight-strength comparison of cylindrical shells with sandwich walls of 17-7PH stainless steel, 7075-T6 aluminum alloy, and AZ 31A-H24 magnesium. Shells were subjected to bending loads. A similar comparison for shells subjected to shear stresses can be interpolated from Figs. 2 and 3.

Fig. 5 supplies the weight-strength comparison for 17-7PH stainless steel sandwich cylindrical shells subjected to bending stresses at two temperatures, 600° and 80°F. A study of Fig. 6 reveals that these shells at 600°F. are more efficient than any of the 7075-T6 solid, waffle-like, or longitudinal stiffened shells at 80°F.

Table 1 gives a comparison of various types of stiffened cylinders under bending loads, similar to that of Fig. 1. Table 1 also indicates the weight penalty imposed by the use of these stiffeners in contrast to sandwich construction.[6,7]

The superiority of sandwich shells over conventional solid shells under other types of loading (axial compression, external pressure, or torsion) is indicated by typical examples in Table 2.

Safety

In various applications, cylindrical structures experience internal pressure accompanied by cyclic torsion, possibly causing fatigue cracks. When developed in the skin, fatigue cracks result in either gradual or explosive failures. The types of failure depend upon the hoop stress and the structural configuration, particularly upon the ratio of stiffener area to associated skin area.[5]

Tests on stiffened cylinders of 2024—aluminum alloy under internal pressure and cyclic torsion—were made by Peters and Dow.[5] Their findings are tabulated in Table 3 and shown in Fig. 7. Hoop tensile stress induced by internal pressure is plotted against reinforcement ratio—the ratio of the cross-sectional area in rings (stiffeners) $A_{r_{red.}}$ to associated skin area lt_s.[12] The X-points represent those cylinders which failed explosively, and the circles represent cylinders which experienced a gradual crack growth. The test points tend to establish a pattern which permits drawing a boundary between the regions of explosive and gradual types of failures.

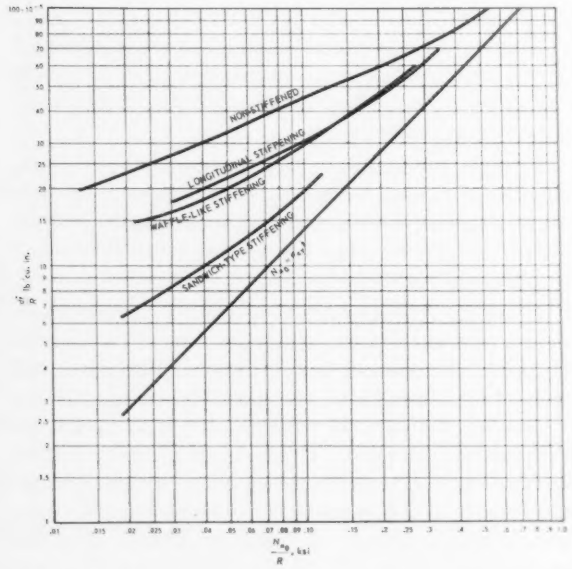

Fig. 1. Weight-strength comparisons of 7075-T6 aluminum-alloy cylindrical shells with various types of stiffening. Shells are subjected to bending loads.

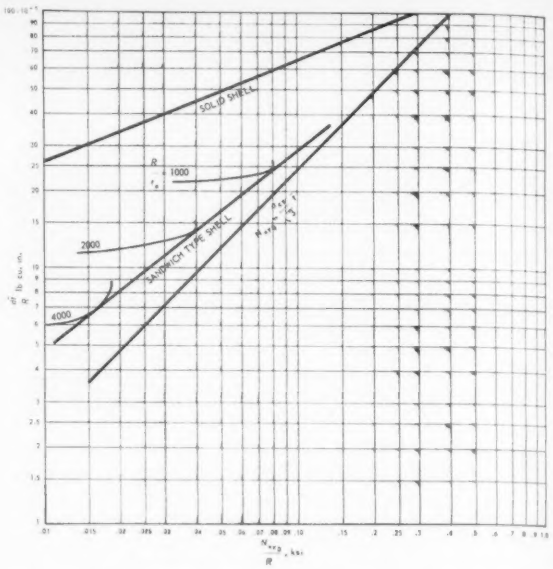

Fig. 2. Weight-strength plot of 7075-T6 aluminum-alloy sandwich cylindrical shells vs. plot of 7075-T6 solid shells subjected to shear stresses ($\delta = 0.03$; $1/r = 1.0$).

Honeycomb, when used as a stiffener to replace the rings and longitudinal stiffeners, will yield a higher ratio of $A_{r_{red.}}/lt_s$ and offers a better assurance in preventing explosive failure.

The ⊕ points in Fig. 7 represent the new locations of the X-points due to the use of Al 3/8-3003-.002P honeycomb in place of longitudinal and ring stiffeners.

The use of honeycomb as a stiffener will change the structural configuration parameter $A_{r_{red.}}/lt_s$ to a higher value, thereby guaranteeing a gradual rather than explosive growth failure (if failure occurs). It will also offer a substantial weight-saving, as shown in Table 4.

Various types of honeycomb could be selected, depending on the required margin of safety and the weight reduction needed. Further testing should verify the above conclusions.

Absorb Vibration and Shock

When conventional structures are used in aircraft and missiles, high noise levels generated by jet engines and vibrations from air turbulence cause structural damage. Figs. 8a and 8b indicate the degree

to which airplane structures are exposed to high engine noise levels. Missiles are affected by this type of noise and even more by transmitted structural vibrations. In solid propellant rockets, the nature and burning rate of fuel are additional sources of vibration. Conventional structures allow the transmittance of undesirable vibrations to the parts of the vehicle carrying sensitive electronic equipment. It is necessary to minimize these vibrations and reduce response of the structure to high noise levels.

The use of honeycomb sandwich in the fuselage or other structural parts of an aircraft or in the cylindrical shell of a missile will normally yield a structure with higher natural frequency. This structure will then be less susceptible than conventional structure to damage in the usual range of excitation frequencies. The Boeing Airplane Company prevented sonic damage in the wing trailing edges of the B-52 and subsequent models by this means. Sandwich construction was also found to be both effective and economical in preventing sonic fatigue damage in the rear fuselage and wing trailing edges of the Boeing 707.

The incorporation of viscoelastic materials in structural components offers a method by which vibrations ordinarily transmitted through the structures can be dampened so that their effect will be minimized. This can also bring about the desired decrease in damage due to vibrations.[18] Adhesive bonded honeycomb structural sandwich in aircraft and missiles thus offers a flexible system for the attenuation of vibration initiated by jet engines or turbulence of air.

Optimization

The problem of plastic design of a structure for minimum weight is a problem of constrained optimization. The unknown functions—stress resultants and thickness parameters for plates and shells—are constrained to lie in a domain defined by the plastic yield condition of the material and the equilibrium equations of the structure, usually in its integral form. Structures designed to give constant rate of energy dissipation per unit volume of face materials can be optimized.[3]

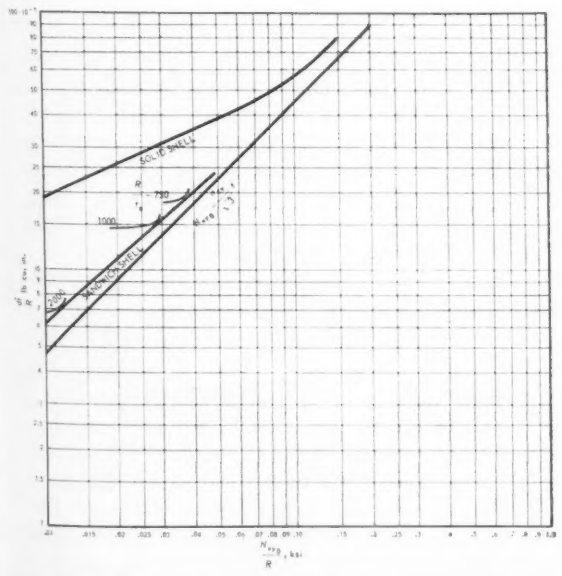

Fig. 3. Weight-strength plot of AZ 31A-H24 magnesium-alloy sandwich cylindrical shells vs. plot of AZ 31A-H24 solid shells subjected to shear stresses ($\delta = 0.03$; $1/R = 1.0$).

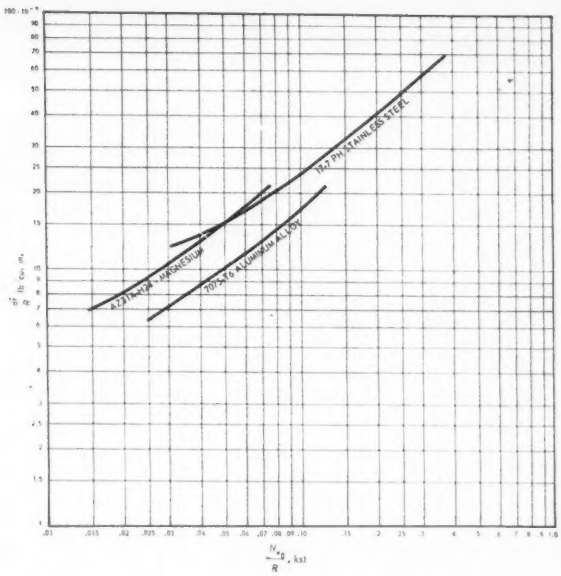

Fig. 4. Weight-strength comparisons of cylindrical shells with sandwich walls of various materials. Shells subjected to bending loads.

For cylindrical shells, the problem is complicated by the fact that the thickness parameter no longer enters homogeneously into the yield condition. However, *this homogeneity can be preserved in shells of sandwich construction.*[4]

A relative minimum for the shell weight is found, for sandwich shells, to give constant rate of energy dissipation per unit volume of face material. In view of the local plane stress conditions prevailing in the faces, this condition will also give an absolute minimum and thus an overall optimum design.[4]

The above conditions, necessary for the optimization of design, could hardly be approached in con-

Table 1. Weight-Strength Comparison of 7075-T6 Aluminum-Alloy Cylindrical Shells With Various Types of Stiffeners

(Shells Subjected to Bending Loads)

N_{x_0}/R, ksi	$dI/R \times 10^8$ lbs./cu.in.			
Stiffener	None	Waffle-Like	Longitudinal	Sandwich-Type
0.025	25	15	18	7.5
	333%	200%	240%	100%
0.050	34	19.8	22	11.5
	296%	172%	191%	100%
0.075	40	25	26.5	15.8
	253%	158%	168%	100%
0.100	45	29	30	20
	225%	145%	150%	100%

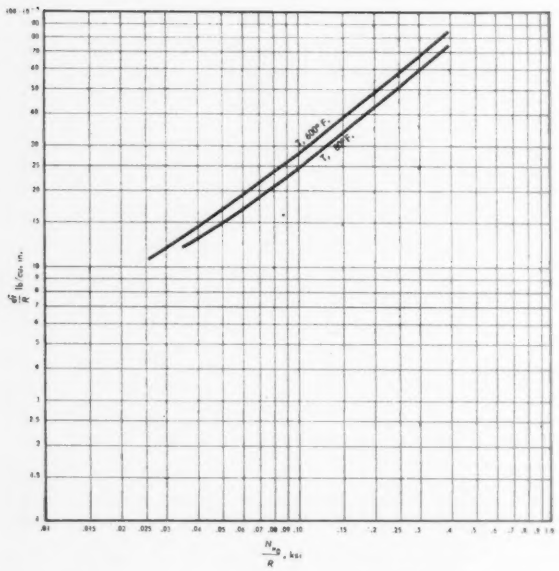

Fig. 5. Weight-strength comparison for 17-7PH stainless steel sandwich cylindrical shells subjected to bending stress for two values of temperature.

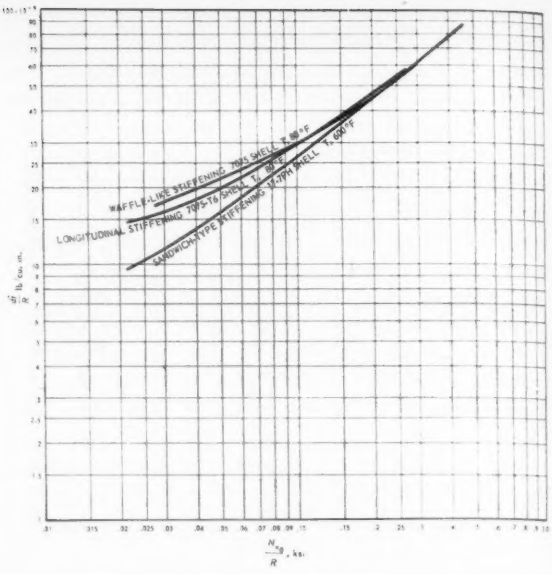
WAFFLE-LIKE STIFFENING 7075 SHELL T, 80°F
LONGITUDINAL STIFFENING 7075-T6 SHELL T, 80°F
SANDWICH-TYPE STIFFENING 17-7PH SHELL T, 600°F

Fig. 6. Weight-strength comparison of 17-7PH stainless steel sandwich cylindrical shells at 600°F. vs. 7075-T6 aluminum-alloy cylindrical shells with waffle-like and longitudinal stiffeners at 80°F.

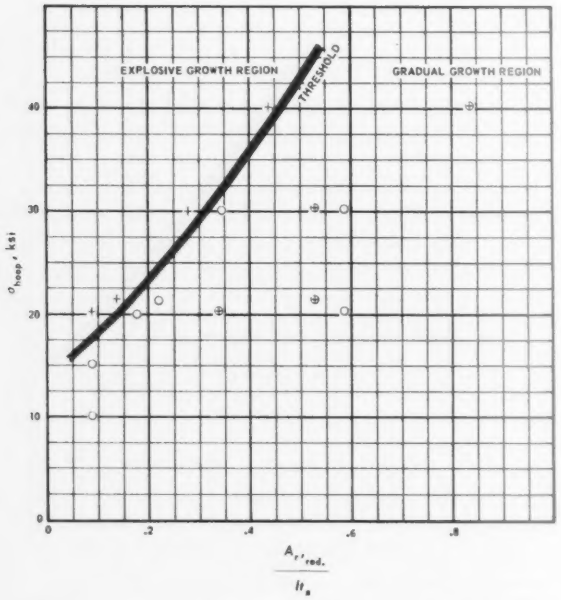

Fig. 7. Regions of explosive and gradual crack growth as determined by tests of 30-in. stiffened cylinder of 2024-T3 aluminum alloy, and anticipated effect of the replacement of stiffener by honeycomb (○ gradual; + explosive; ⊕ relocation of X, anticipated through replacement of stiffener by honeycomb, Al 3/8-3003-.002P).

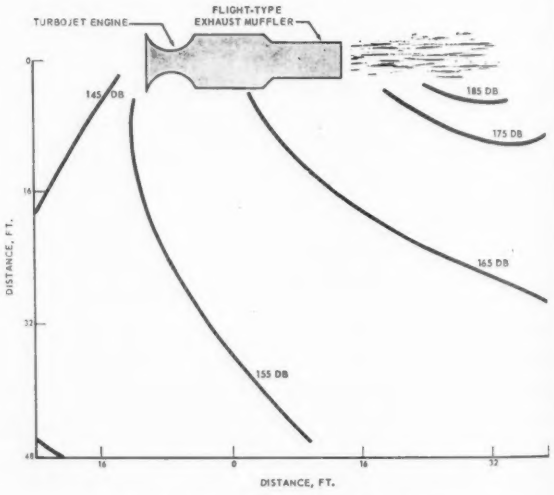

Fig. 8a. Near-field engine-noise contours.

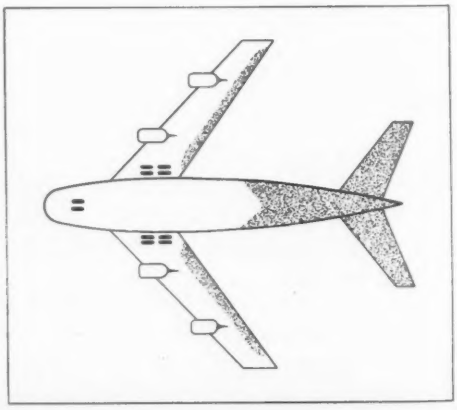

Fig. 8b. Areas of possible damage, bottom view.

Table 2. Comparison of Cylindrical Constructions Sandwich vs. Conventional Shell

Cylinder	Axial Compression		External Pressure		Torsion	Reference
L	120 in.	120 in.	60 in.	120 in.	150 in.	
R	15 in.	25 in.	25 in.	15 in.	25 in.	
Material	S.S.	Al.	Al.	S.S.	Al.	
t_f	0.020 in.	0.020 in.	0.050 in.	0.020 in.	0.020 in.	
t_s	0.250 in.	0.250 in.	0.400 in.	0.250 in.	0.400 in.	
Core	A	B	C	A	D	
Buckling stress 1,000 psi						
Conventional	61	11	..	..	..	(15), (14)
Sandwich	226	23	..	..	..	(10)
Critical stress psi						
Conventional	..	..	7	1.5	..	(15), (16)
Sandwich	..	..	64.4	40	..	(8)
Critical shear 1,000 psi						
Conventional	..	..	..	..	2.62	(15)
Sandwich	..	..	..	..	52.8	(11)

Comparison is carried on an equal weight basis.
A—3/16-17-7PH-.0015P; B—1/4-5052A1-.002P; C—1/4-5052A1-.003P; D—3/16-5052A1-.002P.

Table 3. Structural Configurations vs. Hoop Stress and Results of 30-in. Cylinders

Cylinder*	Skin Thickness t_s, in.	Ring Spacing l, in.	Hoop Tensile Stress σ_{hoop}, ksi	Type of Failure	$\frac{A_{r_{red.}}}{lt_s}$
1	0.040	15.0	20	X Explosive	0.09
2	0.012	7.5	20	O Gradual	0.59
3	0.040	15.0	20	X Explosive	0.09
4	0.012	7.5	30	O Gradual	0.59
5	0.040	15.0	10	O Gradual	0.09
6	0.016	7.5	40	X Explosive	0.44
7	0.032	7.5	21.5	O Gradual	0.22
8	0.025	7.5	30	X Explosive	0.28
9	0.020	7.5	30	O Gradual	0.35
10	0.040	7.5	20	O Gradual	0.18
11	0.040	15.0	15	O Gradual	0.09
12	0.025	15.0	22.5	X Explosive	0.14

* 2024 aluminum alloy.

ventional nonstiffened shells or waffle-like and longitudinal stiffened shells but are relatively straightforward in sandwich design.

Conclusions

It has been found that stiffened cylindrical structures are more reliable than unstiffened shells. Sandwich-type stiffened cylindrical shells are more efficient under bending loads or shear loads than waffle-like stiffened cylinders and longitudinal stiffened cylinders; they are also more efficient than conventional nonstiffened shells under axial compression, external pressure, bending, and combined axial compression and bending.

A relative minimum weight is found for sandwich shells designed to give a constant rate of energy dissipation per unit volume of face material. This condition gives an absolute minimum and thus an overall optimum design.

The threshold between explosive and gradual growth of failure of pressurized stiffened cylinders under cyclic torsion is dependent on hoop stresses and structural configurations. The use of honeycomb as a stiffener offers a wider margin of safety than longitudinal and ring stiffeners and provides substantial weight-saving.

Honeycomb in cylindrical construction offers flexible means for dissipation of or resistance to vibration, shocks, and sonic energy.

References

[1] Harris, Leonard A., Suer, Herbert S., Skene, William T., and Benjamin, Roland J., *The Stability of Thin-Walled Unstiffened Circular Cylinders Under Axial Compression Including the Effects of Internal Pressure*, Journal of the Aeronautical Sciences, Vol. 24, No. 8, pp. 587–596, Aug., 1957.

[2] Klein, Bertram, *Use of Stiffened Cylinders vs. Use of Unstiffened Cylinders*, Readers' Forum, Journal of the Aeronautical Sciences, Vol. 24, No. 9, pp. 703–704, Sept., 1957.

[3] Drucker and Shield, *Bounds on Minimum Weight Design*, ONR Contract C-11, 1956.

[4] Freiberger, Walter F., *On the Minimum Weight Design Problem for Cylindrical Sandwich Shells*, Readers' Forum, Journal of the Aeronautical Sciences, Vol. 24, No. 11, pp. 847–848, Nov., 1957.

(*Continued on page 46*)

Table 4. Anticipated Effect of the Use of Honeycomb as Stiffener

(In Place of Original Stiffener of Table 3)

	With Original Stiffener		Anticipated in Honeycomb* Used as Stiffener		
Cylinder	$\frac{A_{r_{red.}}}{lt_s}$	Failure	$\frac{A_{r_{red.}}}{lt_s}$	Failure	Stiffener % Weight Reduction
1	0.09	Explosive	0.34	Gradual	78
3	0.09	Explosive	0.34	Gradual	78
6	0.44	Explosive	0.83	Gradual	83
8	0.28	Explosive	0.53	Gradual	83
12	0.14	Explosive	0.53	Gradual	78

* Al 3/8-3003-.002P.

The objective of analytical and environmental cooling specifications for airborne electronic equipments would be to achieve reliable thermal performance with minimum penalty to the overall aircraft system.

Analytical and Environmental Cooling Specifications for Airborne Electronic Equipment

Alvin R. Saltzman, MIAS, *U.S. Naval Air Development Center*

In recent years, many new techniques of cooling airborne electronic equipment have been developed that are effective in maintaining electronic components at low-temperature levels. However, the effectiveness of these techniques has been considered from the point of view of only a single electronic package rather than the effect of the package on the performance of the overall aircraft system. There are limitations to all techniques of cooling, as well as penalties such as weight, power, and drag, to the overall performance of the aircraft system.

At the present time, no cooling specification delineates the technical requirements and rules by which the optimum types of cooling techniques could be designed into the electronic equipment package for a specific type (or types) of naval aircraft mission.

The objective of analytical and environmental cooling specifications would be to develop electronic packages which give reliable thermal performance and maintain penalty factors to a minimum.

A review of the technical literature shows that much progress has been made in reducing weight and size of miniature electronic components and subassemblies. However, reduction in weight and volume is not always indicative of penalty reduction to aircraft performance. For certain aircraft missions, the savings in weight achieved by miniaturization may be shown to be a delusion if lower component temperature levels have to be maintained requiring that a considerable amount of low-temperature cooling air be provided by the aircraft refrigeration system. Under these conditions, original calculations of weight can be considerably offset when the penalties of increased amount of cooling air and increased size and drag of the aircraft refrigeration system are figured on an "equivalent" weight basis.

Even when an electronics package is designed to give minimum penalty for a specific type of aircraft and its mission, it does not necessarily follow that the same equipment will give the same minimum penalty for a different type of aircraft having a different type of mission and flight operational characteristics.

To obtain an optimum electronic equipment design for an aircraft system rather than one that only meets an incomplete specification, it is necessary to include a requirement that the design be optimum. A recent progress report[1] from the U.S. Naval Air Development Center (NADEVCEN) on the subject of the development of an analytical cooling specification for airborne electronic equipment outlined the concepts and technical elements that could be used in the formulation of cooling specifications. However, more than a requirement is needed. There must be concurrent and tangible evidence to give assurance that the development is being optimized. Reference 1 recommends that this evidence be obtained by requiring four timely reports covering the four basic steps making up the

Mr. Saltzman received his B.S. degree in chemical engineering from North Carolina State College in 1938 and has done further graduate study at New York and Columbia Universities in the fields of heat transfer and fluid flow. He was employed at the U.S. Army Signal Corps Engineering Laboratories from 1940 to 1944 when part of that activity became a part of the USAF. In 1948, he joined the U.S. Naval Air Development Center, Johnsville, Pa., and is now head of the Environmental Analysis Branch of the Aeronautical Electronic and Electrical Laboratory. He has been active in the development of airborne electronic equipment and associated components to give reliable operation under high temperature as well as other fleet environmental service conditions. He is a member of the American Chemical Society, the IRE, and the IAS.

technical development process. Appropriate subjects for these reports are considered to be definition of the cooling problem, analytical solution of the cooling problem, mechanization of cooling design, and transient environmental verification report.

The first three reports would be considered as Parts I, II, and III of an analytical technical cooling specification and would be so designated. They would be issued at specified time intervals and before there is any hardware development. The fourth report would describe the performance of the equipment under the environmental test conditions which will be specified in the second cooling specification.

In presenting the requirements of a cooling specification, reference 1 makes a distinction between the design of a new aircraft system in which all components are developed simultaneously (Category A) and the utilization of electronic equipments which were originally developed prior to the decision to use them for a specific aircraft (Category B).

Both categories require electronic equipments to give reliable thermal performance throughout the various operations of mission of the aircraft and to be compatible with specific types and sizes of aircraft refrigeration systems.

Category A equipment would also be required to be evaluated to determine whether minimum penalties to aircraft performance are being achieved.

Analytical Specification Requirements Based Upon a Unit Operations Philosophy

In the discussion which follows, two types of unit operations are presented. One refers to the various flight operations which the aircraft is required to go through in the performance of its mission. The second has to do with the unit operations of cooling incorporated into the design of an electronic package and the penalty factors associated with these cooling operations. Those performed by the aircraft influence the type of cooling operations selected for design into the electronic package. In essence, the problem resolves itself into reviewing the flight operations of an aircraft mission and analytically determining the types of cooling operations that are required to be designed into the electronic equipment to provide reliable thermal performance and minimum penalty to the aircraft system.

With reference to the second type, there are known to be many unit operations of cooling, such as air cooling using fin technology, evaporative spray cooling, regenerative packed beds, sublimation, thermoelectrics, thermal insulating barriers, etc. Certain of the operations have been described in references 2 to 7 inclusive.

In addition to the concept of integrally designing cooling techniques into the electronic package as referenced above, there are on the commercial market various heat exchangers and compact cooling component subassemblies which can be connected or inserted into the electronic equipment package. These also are considered within the domain of the second type of unit operation.

The efficiency of the aircraft refrigeration system is affected by the types of flight operations performed by the aircraft. Penalty factors for an aircraft refrigeration cooling system will vary depending upon the types of flight operations being performed. For those equipment packages being supplied the primary coolant by the aircraft refrigeration system, it will be necessary to determine a penalty factor for the combination of aircraft refrigeration system and electronic equipment packages. The type and size of aircraft cooling system and equipment package cooling method selected would be contingent upon whether these provide minimum penalty to the overall aircraft system.

The very interrelationship and dependency of the various technical fields of aerodynamics, aircraft refrigeration systems, and thermal design of the electronic equipment involved in the development of the aircraft system requires close coordination of all activities, and this is an objective of the specification.

Whether an electronic package operates with, or independently of, the central aircraft cooling system, the basic purpose of the cooling operations designed into the package will be to maintain temperatures of reliable levels by providing minimum thermal impedance from critical components to the heat sink of the equipment throughout the various operations of the mission. Analytical calculations will therefore be required in this area and will be called out by the specification.

In order to arrive at a calculation for a minimum overall penalty factor, analysis will also be needed to obtain information regarding penalty values caused by the various unit operations of cooling. For example, for certain operations of flight, there will be a need to decide whether it would be more advantageous to require a greater quantity of low-temperature air as coolant from the central aircraft cooling system. The alternative would be to reduce the amount of air and accept it with an increase of temperature but pay the penalty of additional weight by the requirement for designing into the electronic package a simultaneous heat- and mass-transfer cooling system which uses an expendable coolant.

The calculation of penalty factors will also influence decisions as to whether cooling operations designed into the electronics package shall operate during certain

flight operations independently of the central aircraft cooling system.

Cooling penalties will have to be analyzed jointly to determine if it would be more feasible to supply the same amount of coolant from the aircraft refrigeration system to the electronic package during subsonic and supersonic flight conditions. An alternative would be to provide an excess of coolant during a subsonic flight operation and operate the electronic package as a regenerator, as explained by reference 6, without cooling by utilizing the "cold" absorbed into the equipment during supersonic flight.

The foregoing refers to only a few of the problems involved in obtaining minimum penalty to the overall aircraft system.

Reference 5 describes methods by which cooling hardware integrally designed into the electronic package can serve other equipment functions, such as mounting structure for electronic component parts, thermal barrier, acoustic insulating structure, etc. The utility of cooling hardware for other packaging functions has been referred to as a multifunctionality concept and provides a means of reducing penalty factors chargeable to cooling the electronic equipment. It is the author's opinion that to obtain minimum penalty factors will require the integral design of cooling hardware into the electronics package in a manner such that the multifunctional packaging concept is effectively achieved.

The objectives of the specification are such as to require the coordination and cooperation of the various activities involved in the development of the overall aircraft system. This is particularly evident in the development stage prior to performing any analytical calculations and when the cooling problem must be defined and agreed upon by the various activities involved. The first report, titled *The Cooling Problem Definition*, would be issued for this purpose.

The Cooling Problem Definition

As soon as possible after the award of the contract, the contractor should review the technical requirements expressed by the contracting agency. These requirements will be the technical paragraphs of the contract and of the development specification and the referenced analytical cooling specification. Besides the sources named above, the contractor should consider any other available information bearing on the subject of cooling, even if it is not in the contract or analytical cooling specification. Absence of a real cooling requirement from the contract should not exempt it from consideration in defining the cooling problem.

One purpose of the review is to identify any gaps in the completeness of the analytical cooling technical requirements. This new review should be done by a group of the contractor's engineers who are versed in the problems of cooling, electronics, and aerodynamics and who will be required to work out the analytical solution. If the review identifies any gaps in the completeness of the requirements, information to fill the gaps should be requested from the contracting agency. Should the agency for any reason not be in a position to provide the needed information, the contractor must determine and recommend reasonable assumptions for use instead.

Another purpose of the review is to identify any areas of possible misunderstanding or ambiguity in the requirements. The contractor should re-express the questionable requirements in a way that removes the ambiguity, and then request concurrence or clarification by the contracting agency. When these initial and probably informal steps have been taken, the contractor should next draft his report, *The Cooling Problem Definition*. This report should contain a listing and definition of all the technical requirements and operations that have a direct bearing on the merit of the electronic equipment to be developed for the mission (or missions) of specific type (or types) of aircraft. Within the listing there should be exposition to establish the contractor's understanding of those areas that are unusual or involved. Any assumptions generated by the contractor should be accompanied by justifications for their selection. The source of each requirement should be shown, preferably in tabular form. This report could logically be divided into distinct sections, separating the requirements into reasonably independent groups, examples being compatibility of cooling design with other electronic equipments in the aircraft compartment, listing of proposed cooling operations, compatibility of cooling operations with aircraft refrigeration systems, transient operation environment, physical environment, and maintenance.

Analytical treatment of cooling requirements is functionally part of the next phase. However, any analytical results that are a refinement of the requirements and that are available at the time *The Cooling Problem Definition* is prepared can properly be made part of the report. However, it would appear best to restrict the analytical work in the first report to subjects such as refining of the various environments and groups mentioned above rather than include derivation of cooling equipment parameters.

Although the submission and approval of the contents of this first report indicate that the contractor's technical development problem is then as well defined as any reasonable effort can make it, amendments should be added if there are later changes in requirements.

The Analytical Solution

The second of the four reports, *The Analytical Solution*, presents the analytical unit operations of the cooling problem requirements. The results of the analysis should be a complete definition of all the unit operations of cooling design parameter values and overall electronic cooling equipment characteristics which will provide an optimum solution to the problem of cooling the electronic equipment throughout the various operations performed by the aircraft system during its mission. Quantitative justification for all selections must be given. All engineering decisions made

during the analytical analysis, including working assumptions and compromises, should be fully and quantitatively justified. Each justification should be based on optimum cooling system performance. Where parameter tolerances are an important part of an equipment characteristic, they should be established in the report. The overall cooling system effectiveness of the final optimum analytical solution should be shown and based upon the following:

(1) That the electronic equipment throughout its "mission operations" will maintain temperances within the equipment at reliable operating limits.

(2) That the type of unit operations of cooling design incorporated into the electronic equipment gives the minimum penalty to the overall aircraft system.

The Analytical Solution should have logical and reasonable justification as its theme. Consideration of specific cooling hardware must be avoided, but functional block diagrams to illustrate the unit operations of cooling conceptual schemes are desirable. Any known alternate conceptual schemes must be considered and their rejection justified.

An essential consideration in the optimizing of cooling design will be the sensitivity of the cooling system to change in the values of parameters of operations for a type (or types) of mission.

All of the derived unit operations of cooling making up the overall equipment cooling system should be summarized in tabular form, preferably in the front section of the report. For readability the body of the report should be supplied liberally with tables and summaries. For the same reason lengthy mathematical derivations should appear as appendices.

The second phase report should result in a detailed cooling specification of the equipment characteristics. The final tabulated parameter values should be those to which the initial mechanization report will be directed. With this information, a completely detailed development specification could be prepared, if desired.

The Mechanization Cooling Report

The investigational hardware work done with the intent to obtain information in support of the analytical work is wholly proper. However, any move into the hardware phase that commits the design before the analytical phase is completed should not be permitted for equipment in Category A.

The mechanization report should show how the results of the analytical solution, the various unit operations of cooling system parameters, and other characteristics are translated into hardware. Selection of the mechanization methods used should be justified by comparing them with alternate methods of cooling.

Timing of *The Mechanization Cooling Report* is important. One of the objectives of the report would be to encourage cooling engineering rather than empirical design to reduce the probability of rationalizing and aid the contracting agency during the early stages of the development. An early report is necessary for these purposes. If the *Report* is delayed until a satisfactory verification shows that the equipment is in final development, it serves only as a review and a justification of a finished development. The best answer is considered to be a report prepared just before fabrication with an amendment based on the final configuration.

Enumeration of Technical Requirements of an Analytical Cooling Specification

The analytical specification should specify certain technical requirements which serve as rules in determining the optimum cooling system. The following two categories of technical requirements are considered necessary:

(1) The information to be given to the contractor so that he can proceed to define the cooling problem and make calculations for determining the various unit operations of cooling required.

(2) The fundamental factors which should be considered in an evaluation of penalties of the equipment cooling package to the overall "aircraft system."

The difficulty of defining the cooling problem and analytically determining the types of cooling techniques to be designed into an electronic equipment package can be considerably reduced depending upon the amount of information available to the contractor at the time of awarding contract. A knowledge of the type of aircraft refrigeration system and its capacity would eliminate the need of the contractor to make certain assumptions in this area. If information were also available as to the temperature, pressure, and amount of primary coolant, external heat loads, as well as how these varied throughout the various operations of the flight mission, then the problem of cooling design for the electronic equipment would be considerably simplified.

It can be anticipated that information to design by will not always be ideal or complete and certain assumptions will be required. In order that assumptions be meaningful, the contractor's engineering personnel will have to be technically proficient in scientific fields such as aerodynamics, heat transfer, as well as electronics.

The second category concerns the fundamental factors which should be considered in the evaluation of penalties of the electronic equipment to the aircraft system. In the final analysis, the criteria for analytical evaluation of the penalties to the electronic design should be analyzed along the same lines as the aircraft refrigeration system and the penalties charged to the system in general as described in references 8 and 9.

The fundamental factors which should be considered in an evaluation of penalties to an electronic equipment cooling system are (1) weight chargeable to the electronic equipment, (2) power requirement of the aircraft charged to the electronic equipment, (3) drag caused to the aircraft system by the electronic equipment and its cooling components, and (4) space requirement. These factors would apply only to equipments in Category A.

In general, the cooling system exhibiting the smallest values of the factors adversely affecting performance is required. In the actual case, the relative magnitude of weight and power, for example, will vary widely for different types of aircraft systems. Further, it is frequently possible to reduce the power required of the aircraft by increasing weight. It is, therefore, necessary to use methods of translating the various factors of weight, power requirements, and drag to some common unit. For the specification containing the analytical solution, an equivalent weight could be selected as the common unit because all systems and all components possess weight. The actual weight can then be used directly. It is then necessary to determine the power input to the system and any drags imposed by the system and to translate these factors into the equivalent weight unit.

The power (or drag) equivalent weight is then that weight that would have approximately the same effect in the aspect of aircraft system performance being considered as a given power requirement (or drag imposition). The total equivalent weight of a system is the sum of the actual weight, the power equivalent weight, and the drag equivalent weight.

The factor used to translate power and drag to an equivalent weight depends on the type of aircraft system, its flight characteristics, and the aspect of performance chosen as the most significant in a particular case.

Among the aspects of performance recommended by reference 8 which can be used as evaluation criteria are range, flight duration, and rate of climb. The first two are particularly applicable to bomber and transport aircraft, while the third may be more significant for fighter-type aircraft. From the point of view of unit operations of a flight mission, the penalties would have to be calculated for each operation of the aircraft and a summation made of all the penalties involved. The electronic equipment cooling system which has the minimum equivalent weight penalty and is capable of maintaining critical temperatures within the equipment at the lowest value would be selected for usage.

The approximate effect of a small change in the various penalty factors can be determined by an equation which describes the aspect of performance and the partial derivative of that equation with respect to the factors affected by the cooling system. The procedures are presented in detail in reference 8.

Environmental Verification Report on Cooling Design

The three reports previously discussed, which are part of the analytical specification, contain engineering decisions whose correctness depends upon the theoretical "know-how" of the vendors and contracting agency.

To check these decisions leading up to and including the mechanization report, there is a need for a verification environmental specification and environmental report.

The environmental specification would call out requirements for simulating the transient environment of aircraft missions and determining thermal performance and certain penalties of the electronic equipment under various flight simulated operations.

Transient environmental evaluation of airborne electronic equipment is a complicated subject involving many technical areas. Since this report emphasizes analytical procedures, no attempt will be made at this time to present the various ramifications of the subject in detail. It is mentioned, however, that the availability of suitable environmental facilities is a realistic and primary consideration in specifying and simulating environmental requirements. It may be that the specification requirements will have to be of two types—transient environmental requirements for electronic systems and steady-state "peak" testing. The latter would allow the equipment manufacturer to test under steady-state conditions the thermal performance of equipment cooling design under severe ambient temperatures. With regard to the former, Government as well as commercial activities having adequate facilities could subsequently evaluate various equipments under simulated transient environmental flight conditions and thus simultaneously check specified analytical performance and evaluations performed by individual equipment manufacturers.

Conclusion

Airborne electronic equipments should function reliably and with minimum penalty to the overall aircraft system. The requirement for analytical cooling specifications is recognition of the fact that the influence of thermal environmental conditions of flight has to be taken into consideration in the early design stages of the equipment package.

References

[1] *Progress Report, Development of Cooling Specifications for Airborne Electronic Equipment*, Report No. NADC-EL-59113.

[2] Saltzman, Alvin R., Plizak, Bruno T., and Tomko, Leonard F., *Electronic Equipment Cooling by Simultaneous Heat and Mass Transfer*, Aeronautical Engineering Review, Vol. 16, No. 5, May, 1957, pp. 67–74.

[3] *Interim Report, Investigation of Analytical Design Techniques for Electronic Equipment Insulating Barriers*, Report No. NADC-EL-5764.

[4] *Interim Report, Electronic Equipment Cooling by Simultaneous Heat and Mass Transfer*, Report No. NADC-EL-56106.

[5] *Simultaneous Heat and Mass Transfer Cooling of Airborne Electronic Equipment*, Proc. of National Conf. on Aeronautical Electronics, May, 1958.

[6] Saltzman, Alvin R., Plizak, Bruno T., Tomko, Leonard F., and Nycum, James, *Regenerative Heat Sinks for Airborne Electronic Equipment*, Aero/Space Engineering, Vol. 18, No. 12, Dec., 1959, pp. 26–31, 53.

[7] Saltzman, Alvin R., *Thermal Application of Catalytic Chemical Kinetic Theory*, Aero/Space Engineering, Vol. 19, No. 6, June, 1960, pp. 28–31, 37.

[8] *Equipment Cooling Systems for Aircraft*, Report No. WADC-56-353, WADC, Dayton, Ohio, Jan., 1958.

[9] *Equipment Cooling Systems for Aircraft*, Report No. WADC-54-359, WADC, Dayton, Ohio, Sept., 1954.

Moon, age 14 days
Spiral nebula in Ursa Major
Spiral nebula in Virgo
Space
Spiral nebula in Andromeda
Spiral nebulae in Canes Venatici
Filamentary nebula in Cygnus
Globular star cluster in Canes Venatici
Saturn and ring system
Head of Halley's Comet
Nebula in Sagittarius

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Air-Breathing Jet Engines . . .

(Continued from page 31)

The following are some of the developments that would tend to make air-breathing engines competitive with rockets in such applications:

(1) Use of turbine entry temperatures above 2,500°F. for nonafterburning turbojets.

(2) Integration of turbojet and ram-jet as a combination power plant, with good performance from take-off to hypersonic speeds.

(3) Successful application of supersonic burning for ram-jets, with a resultant increase in the engine speed limit.

The outstanding development problems of air-breathing engines for accelerating missions may be listed as follows:

(1) Large engine geometry changes required for efficient operation over a wide speed range.

(2) Cooling of structural components at high speeds.

References

[1] Arens, M., *A Comparison of Turbojets and Ramjets for High Speed Flight*, Jet Propulsion, Vol. 28, No. 9, Sept., 1958.

[2] Daum, N., *The Griffon Aircraft and the Future of the Turbo-ram-jet Combination in the Propulsion of Supersonic Aeroplanes*, Journal of RAeS, Vol. 63, No. 582, June, 1959.

[3] Gross, R. A., *Research on Supersonic Combustion*, ARS Journal, Vol. 29, No. 1, Jan., 1959.

[4] Gross, R. A., and Oppenheim, A. K., *Recent Advances in Gaseous Detonation*, ARS Journal, Vol. 29, No. 3, March, 1959.

[5] Nicholls, J. A., *Stabilized Gaseous Detonation Waves*, ARS Journal, Vol. 29, No. 8, Aug., 1959.

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Sandwich Cylinders (Continued from page 37)

[5] Peters, Roger W., and Dow, Norris F., *Failure Characteristics of Pressurized Stiffened Cylinders*, NACA TN 3851, Dec., 1956.

[6] Peterson, James P., *Weight-Strength Studies of Structures Representative of Fuselage Construction*, NACA TN 4114, Oct., 1957.

[7] Peterson, James P., *Bending Tests of Ring-Stiffened Circular Cylinders*, NACA TN 3735, 1956.

[8] Raville, Milton E., *Buckling of Sandwich Cylinders of Finite Length Under Uniform External Lateral Pressure*, FPL 1844-A, FPL 1844-B, 1955.

[9] Norris, Charles B., and Zahn, John J., *Design Curves for the Buckling of Sandwich Cylinders of Finite Length Under Uniform External Lateral Pressure*, FPL 1869, 1959.

[10] March, H. W., and Kuenzi, E. W., *Buckling of Cylinders of Sandwich Construction in Axial Compression*, FPL 1830, 1957.

[11] March, H. W., and Kuenzi, E. W., *Buckling of Sandwich Cylinders in Torsion*, FPL 1840, 1958.

[12] Dow, Norris F., and Peter, R. W., *Preliminary Investigation of the Failure of Pressurized Stiffened Cylinders*, NACA RML 55 D156, 1955.

[13] Timoshenko, *Theory of Plates and Shells;* McGraw-Hill Book Co., Inc., New York, 1940.

[14] Sechler, *Elasticity in Engineering;* John Wiley & Sons, Inc., New York, 1952.

[15] Roark, *Formulas for Stress and Strain;* McGraw-Hill Book Co., Inc., New York, 1954.

[16] Wood, J. D., *The Flexure of a Uniformly Pressurized, Circular Cylindrical Shell*, APM 13, 1958.

[17] Haft, Everett Eugene, *Elastic Stability of Cylindrical Sandwich Shells Under Axial and Lateral Load*, FPL 1852, 1955.

[18] Plass, H. J., Jr., *Damping of Vibrations in Elastic Rods and Sandwich Structures by Incorporation of Additional Visco-elastic Material*, Proc. of Third Midwestern Conf. on Solid Mechanics, 1957.

(Part II, which concludes this paper, will appear in the September issue. It will discuss uniformity of the mechanical properties of the core in cylindrical sandwich construction.—ED.)

Attention IAS Members!

In accordance with plans reported in the June issue of Aero/Space Engineering, *the October, and first, issue of IAS News (prepared in newsletter format) will be published and mailed to the Institute's more than 16,000 graded members on Sept. 15th and on the 15th of each succeeding month.*

Plans to increase the technical article content of Aerospace Engineering *will take effect with the October issue, which will continue to be published and mailed on the first of each month to IAS members plus several thousand other subscribers.*

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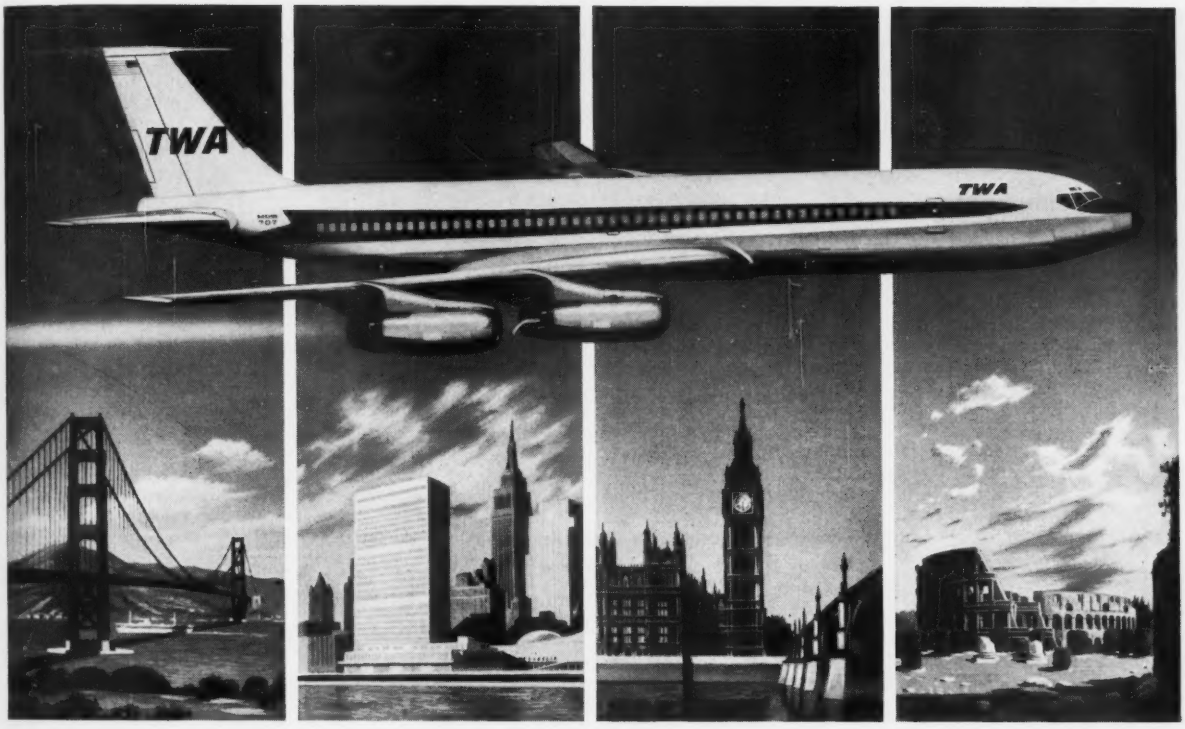

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(Official photograph U.S. Navy)

A Committee representing members of the Los Angeles Section presents a check for Navy Relief to Capt. Robert L. Townsend, USN, Commanding Officer of the U.S.S. "Kearsarge," following May 16 field trip aboard the aircraft carrier. *Left to right* are William L. Sparks; Ronald E. Rainey, IAS Los Angeles Section Coordinator; Captain Townsend; Charles H. Christenson, Section Vice-Chairman; John Clauss, Jr., Chairman of Field Trips Subcommittee; and Donald Mulholland.

Continued from page 22

the Section's annual dinner meeting for the distaff side on May 18.

Holder of an almost incredible number of world aviation speed records for both jet and reciprocating aircraft, Miss Cochran has probably been awarded more medals, citations, and honors than any other woman flyer in the world. She is, at the same time, a highly successful business woman.

Honors she has received include the Clifford Burke Harmon Trophy of the International League of Aviators; de la Vaulx Medal of the Fédération Aéronautique International (FAI); Gold Medal of the FAI; Woman of the Year in Business; Distinguished Service Medal of the United States; Cross of the Legion of Honor of France; Medal of Air, also of France; and French Air Force Wings. She has served as president of FAI for two consecutive terms and is the First Vice-President of the National Aeronautic Association, the U.S. affiliate of the FAI.

Miss Cochran focused her discussion on her concern for internal developments in Russia. She first visited the U.S.S.R. in 1950 as a guest of the United States embassy. At that time she felt that chances for internal overthrow of the communist system were good, noting that living conditions were poor and the Russian people apathetic. She also noted the tremendous industrial development going on in Russia, especially at Tula, south of Moscow.

Returning to Russia in 1959 as President of the FAI, Miss Cochran was surprised at the advancement of the living standards and the attitude of the Russian people. She now feels that present Russian internal affairs are such that there is no chance that the Russian populace will attempt to replace their present system.

Cautioning that if we are to survive the threat of Russia, we must always be alert and prepared, Miss Cochran expressed her belief that Americans must put less emphasis on luxuries and personal comfort and more on a greater effort to keep this country strong against external threats.

JAMES P. LOOMIS
Secretary

Los Angeles Section

Carrier Field Trip Highlight of May Activities

The May 24 specialists' meeting heard **Dr. Vernon H. Blackman,** Technical Director of MHD Research, Inc., discuss **"Magnetogasdynamic Experiments."** Dr. Blackman surveyed the various techniques and limitations for producing ionized gas streams, with regard to both thrust generation and power extraction. Detailed results of measurements of the flow properties were described for an arc-heater facility.

▶**A. Scott Crossfield,** Chief Test Pilot for North American Aviation, Inc., spoke on **"Experience With the First Manned Spacecraft"** at the May 19 dinner meeting. Mr. Crossfield related his recent flight experiences with the X-15, augmenting his discussion with movies of flights and landings. Guest chairman for the meeting was Col. Dean Hess, Director of the Los Angeles USAF Office of Information.

▶Through arrangement with Vice Adm. C. E. Ekstrom, Commander, Naval Air Force, U.S. Pacific Fleet, and Capt. R. L. Townsend, Commanding Officer, U.S.S. "Kearsarge," 200 members of the Section enjoyed a day aboard the aircraft carrier "Kearsarge" on May 6. The Navy went all out to show many detailed areas of the carrier and active examples of the carrier's activities. Antisubmarine warfare operations using S2F airplanes and helicopters included locating an imaginary submarine and the bombing operations needed to destroy it. Demonstrations were also given of jet aircraft performing touch-and-go operations on the carrier, as well as landings and catapult launchings. Included in the activities was a man overboard exercise, with appropriate carrier gyrations and pickup by lifeboat.

▶**Aviation's Gliding Heritage** was the subject of the May 13 historical meeting. Jointly sponsored by the IAS and the Southern California Soaring Association, the meeting presented **Dr. Wolfgang B. Klemperer** of Douglas Aircraft Co., Inc., as guest speaker. Dr. Klemperer developed a perspective for the many specific contributions which glider design and operation have made to aircraft. Films made by Fokker in 1921 of early glider flights by Dr. Klemperer were a highlight of the presentation.

S. J. COLBY, *Secretary*

Omaha Section

Electrical Propulsion Systems

William R. Corliss, Design Engineer for The Martin Company's Nuclear Division, discussed the development of electrical propulsion systems for space applications at the May 20 luncheon meeting.

Mr. Corliss treated the basic concepts of ion and plasma accelerators including the purely electrostatic ion systems which are currently receiving the most attention. He also cited difficulties that have been encountered in the areas of space charge neutralization and electrode sputtering. The importance of the power supply specific weight and reliability was shown.

Finally, Mr. Corliss discussed several barrier problems hindering the present development programs and explained some suggested solutions.

MICHAEL MCALISTER, *Secretary*

San Diego Section

Space Propulsion

Al Negro, Senior Applications Engineer for the Rocketdyne Division of North American Aviation, Inc., addressed the May 3 meeting on the subject of **"Spacecraft Propulsion Systems."**

The discussion, which was classified, touched on the evolution of present and future chemical systems, nuclear engines, and electric systems.

WALTER P. ROBINSON

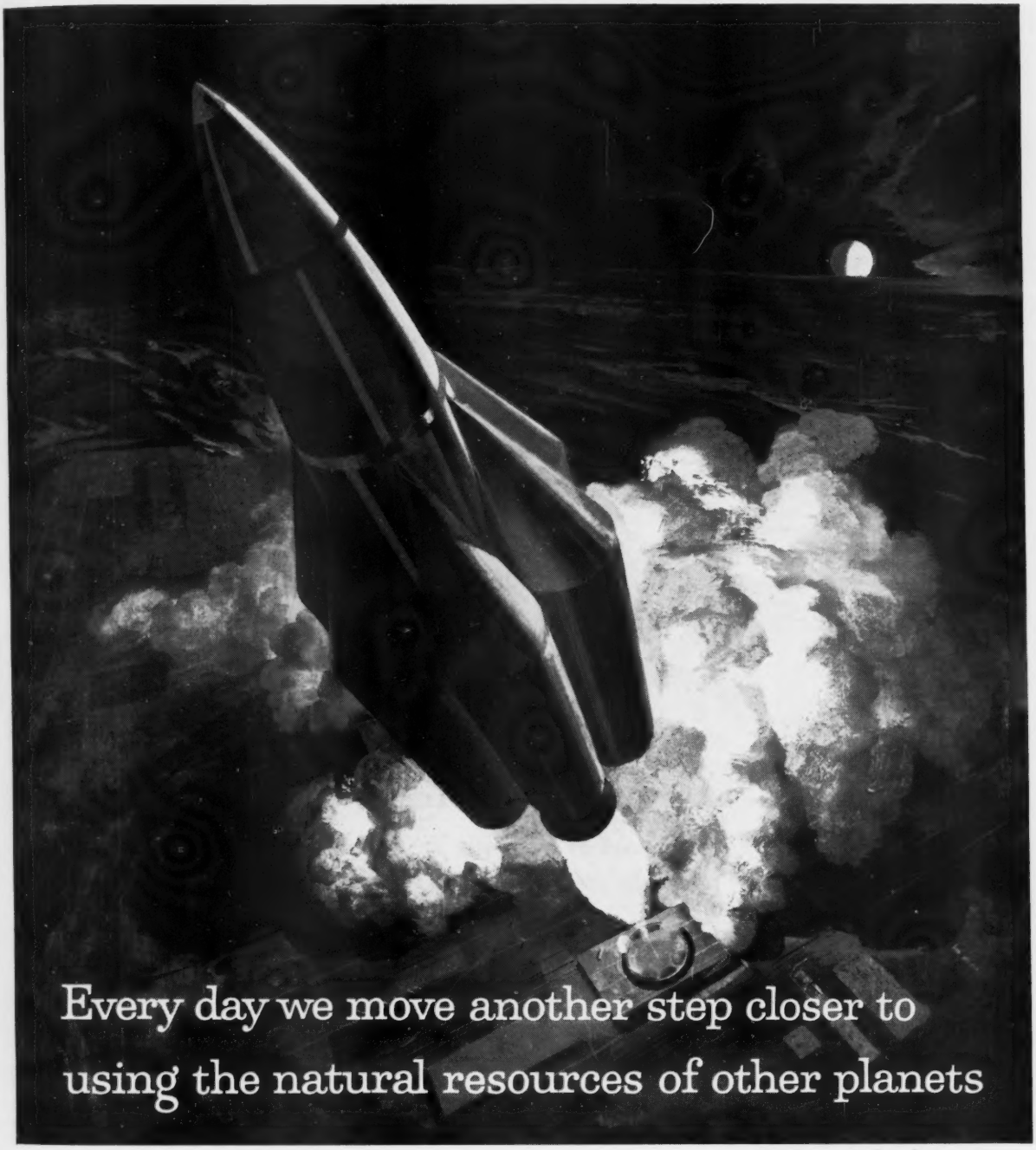
San Francisco Section

Biomedical Aspects of Weightlessness

Stating that certain effects of weightlessness, such as diminution of muscle tone, neuromuscular coordination, and calcification in bones, appear at present to pose no obstacle to putting men in space, **Dr. Heinrich W. Rose,** Research Staff Scientist, Lockheed Missiles and Space Division, discussed **"Biomedical Aspects of Weightlessness"** before the May 19 Section meeting. Dr. Rose defined weight as being equal to the summation of external forces acting on a body, citing the case of an object falling in a vacuum as an illustration of weightlessness (zero *g*).

Dr. Rose pointed out that the human body has a number of biological elements sensitive to attitude and motion. Certain corpuscles around bone joints, for example, tell position of the extremities; nerve endings in skin indicate pressure; and the inner ear mechanism provides the brain with motion and attitude stimuli. The clue to the vertical reference is provided by the eyes.

To perform zero-*g* experiments requires a Keplerian ellipse in which the external forces—e.g., drag—acting on the body are



Development of nuclear power, utilized in space ships like this Douglas concept, will speed the day when man will travel in outer space and use its resources.

Air Force space studies aimed at cracking military problems also reveal potential civilian benefits

Progress in space research is so rapid that consideration must now be given to projects you'd have scoffed at a few years ago. For instance, development of a nuclear rocket could drop payload costs so low that it would be economically worthwhile to import rare materials from other planets.

Projects such as this are the daily fare of engineers at Douglas. Right now they are studying the many problems related to interplanetary exploration: Can humans survive? What about temperature, gravity, water, food . . . and fuel for the return trip?

Douglas has been finding answers to such problems since 1941. These answers are seen in action every time a Douglas-built Thor boosts another payload into space.

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made to cancel out. Up to now, 1 min. of weightlessness is about the maximum that a human body has experienced. The X-15 airplane at full speed is expected to extend this period to about 5 min., Dr. Rose said, and project DynaSoar will double this figure. Of 47 persons subjected to weightlessness by use of airplane techniques, 22 found it a pleasant sensation, 11 reported minor disorientation, and 14 suffered vomiting. These results, Dr. Rose said, do not confirm the dire predictions of 15 years ago.

A number of the more important experiments in the field have dealt with the effects of weightlessness on the heart and circulation. Experiments on both animals and humans show that the after-effects of a zero-*g* state are the greatest concern. For example, upon return to a one-*g* force field from a zero-*g* environment, heart rate is found to increase significantly. It is believed that persons who have been at a zero-*g* condition for prolonged periods may have to be conditioned gradually to a one-*g* environment, somewhat analogous to a deep-sea diver's being brought to the ocean surface by stages.

NORMAN BERGRUN, *Secretary*

Tulsa Section

Flight Test Center at Work

Following dinner and a tour of the Midwestern Instruments facilities, IAS members attending the May 20 meeting heard **Brig. Gen. John W. Carpenter, III,** Commander, Air Force Flight Test Center, Edwards AFB, discuss the Center's activities.

Supplementing his presentation with slides and film, General Carpenter explained the mission and facilities of the Test Center, stating that the test program covers the realm of flight from the low-speed helicopters to the supersonic X-15 airplane and various missiles. Testing is conducted for the Air Force, Army, and Navy. The NASA, by itself and in cooperation with the Services, is also actively at work. Facilities are also available for civilian contractors on a "reimbursement and no interference" basis. The film showed many spectacular shots of test work on airplanes, the test track, missile engine test facilities in operation, and other activities.

P. C. JOHNSON, *Recording Secretary*

Washington Section

Project Mercury Director Addresses Final Meeting

The final dinner meeting of the 1959–1960 season featured **Robert R. Gilruth,** Director of Project Mercury for NASA, as guest speaker. Mr. Gilruth discussed **"Manned Space Flight—Present Status and Future Steps,"** basing his presentation on the paper which he gave at the IAS Manned Space Stations Symposium in April, and which appeared in the May issue of AERO/SPACE ENGINEERING.

Mr. Gilruth made note of the first test with a McDonnell-built Mercury capsule on May 9, a successful test of the recovery chute after a rocket-propelled launch from Wallops Island.

In reply to questions, Mr. Gilruth agreed that orbiting of biological specimens is needed, but pointed out that recovery is required and so far recovery attempts have been unsuccessful, though work is continuing in this area. With respect to the philosophy of the "pilot" having control even if it was not sure that he could handle the task, it was stated that a maximum training effort for all situations was in progress, that the mission would first be flown unmanned, and that the astronaut would utilize the automatic control but would be able to override it if desired.

Communication would be available *most* of the time—periods of a few minutes each would exist when communication would not be possible within geographic and cost limitations. Electrocardiogram and other body measurements would be made during the flight.

Replying to a question with reference to escape on the pad (or immediately thereafter) if the pilot had blacked out, Mr. Gilruth noted that there would be four sources for initiating escape—the astronaut, the block house, an abort-sensing automatic system on the booster, and control central. No manned flight will take place until everything is ready.

Other features of the meeting included the introduction of local high school students whose science fair exhibits had been judged outstanding in the aerospace field by IAS Section representatives.

HAROLD ANDREWS, *Secretary*

Wichita Section

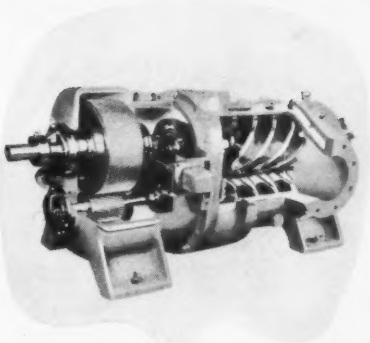
Crane Helicopters

Lloyd R. Novak addressed the May 3 joint meeting of the IAS and the American Helicopter Society, discussing design concepts of the 120 crane helicopter. Mr. Novak, Project Engineer, Preliminary Design, McDonnell Aircraft Corp., speaking on **"The Evolution of the McDonnell Model 120 Crane Helicopter,"** presented several of the challenging engineering features of this new crane-turbine-power-pressure-jet, single-place, cargo-type helicopter. He described it as a small, simple machine designed for light-load lifting of various sorts, with applications for troop movement, ambulance work, warehousing, light-weapons carrying, rescue, and fire fighting. The design concepts were held to be unusual in that they stress simplicity, producibility, ease of maintenance, low cost, and ruggedness at the expense of performance and weight.

ROBERT K. WATTSON, JR., *Chairman*

ATTENTION IAS MEMBERS!

In accordance with plans reported in the June issue of Aero/Space Engineering, *the October, and first, issue of IAS News (prepared in newsletter format) will be published and mailed to the Institute's more than 16,000 graded members on Sept. 15 and on the 15th of each succeeding month.*



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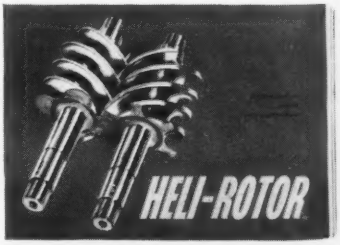

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Thin pin plates and fins make heat exchanger "sandwiches"

Corrugated foil makes fins for heat transfer

Mounting plate for electronics has built-in heat exchanger

new ideas on "heat sink" problems

Here are a few interesting new "sandwiches" Janitrol has cooked up to cope with new heat transfer problems and still keep weight and size down. The materials—stainless and aluminum—are often thinner than the metal foils used in packaging. Yet they are made into rigid, reliable structures for handling air or liquids at high pressures and temperatures.

The plates or "pin type" structures shown above left are quite exceptional in their performance and flexibility: we are able to produce plates with pins as short as 1/32" and in almost unlimited configurations. Structures can be built in almost any size or shape, with relatively simple manifolding. Another design—corrugated foil—is shown above right, brazed to plates, with passages alternating in direction. In some cases both pin and fin structures can be used effectively together.

A good example of heat transfer for electronics is also shown above. In this instance, the mounting plate for diodes and other components is itself a heat exchanger. Heat input to the plate is dissipated to the air stream mainly through the finned section. To get optimum results on design problems such as these calls for precisely the kind of experience Janitrol has been piling up for 15 years.

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AEROSPACE *Reviews*

. . . current literature of aeronautical engineering and space technology

THIS SECTION reviews important periodicals, technical and research reports, and books received in the IAS Library in order to provide basic documentation for engineers and scientists.

INTERNATIONAL AERONAUTICAL ABSTRACTS, published as an insert in each issue, is an accelerated reviewing service covering worldwide scientific and technical literature. This work is performed by the IAS Staff and is supported by the Air Force Office of Scientific Research of the Air Research and Development Command.

For a listing of the principal periodicals received in the IAS Library, please refer to the January, 1959, issue.

The AERO/SPACE ENGINEERING INDEX, formerly the AERONAUTICAL ENGINEERING INDEX published since 1947, provides an annual cumulation of the materials reviewed in this section.

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Acoustics, Sound, Noise

Acoustic Streaming Near a Heated Cylinder. R. M. Fand and J. Kaye. *ASA J.*, May, 1960, pp. 579–584. 11 refs. USAF-sponsored photographic study of a new type of streaming near a heated horizontal cylinder appearing in the presence of a horizontal transverse sound field. Smoke has been employed as the indicating medium in the investigation.

Notes on the Results of Recent Tests of a Momentum Exchange Type Silencer for Turbojet Engines. E. Stringas. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 162A.* 15 pp. Brief review of momentum exchange theory for jet noise suppression. Experimental results from scale model tests are included. These data exhibit peak to peak attenuation of 20 db. along maximum exhaust noise azimuths at a nozzle pressure ratio of 3.1.

By-Pass Engine Noise. F. B. Greatrex. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 162C.* 19 pp. Discussion of the jet mixing process and optimum jet arrangement, showing that the jet noise of the by-pass engine, of by-pass ratio around 1, designed for efficient mixing of by-pass and hot gas streams before being discharged to the atmosphere, will be some 4 db. quieter than if the two streams are discharged separately.

Aircraft Noise. *Bristol Siddeley J.*, 2nd Quart., 1960, pp. 60–63. Discussion of noise generation covering, in particular, generation of jet noise, noise measurement and human reaction to noise, and methods of jet noise reduction.

Methods of Measuring the Loudness of Compound Acoustic Signals. Jan Ryll-Nardzewski. *Vibration Prob. Proc.*, No. 2, 1959, pp. 3–16. Presentation of a method based on the assumption that the loudness of the compound signal is a linear combination of component loudnesses.

Nouvelles Techniques dans la Réduction du Bruit sur Hélicoptères. Harry Sternfeld, Jr. *Tech. & Sci. Aéronautiques*, Sept.-Oct., 1959, pp. 319–324. In French. Presentation of experimental results on the noise reduction in turbine powered Vertol 107 helicopter.

Sonic Boom—Limitations on Supersonic Aircraft Operations. D. W. Patterson. *Aero/Space Engrg.*, July, 1960, pp. 20–24, 44. Discussion of the most favorable speed-altitude schedule for a supersonic transport or bomber, with minimum shock-wave noise as the prime consideration. The propagation of shock waves is discussed for the case of a homogeneous atmosphere and also for a normal atmosphere exhibiting temperature and wind gradients. The most recent experimental results and the available theory concerning the "sonic boom" are discussed.

Shock Wave Noise of Supersonic Aircraft. I. L. Ryhming, Y. A. Yoler, and Y. Aoki. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 166 B.* 12 pp. Investigation using the theoretical methods developed by Whitham and Walkden to study the possibilities of using aerodynamic interference to reduce or suppress the shock wave noise due to lift of conventional aircraft. Wind tunnel tests with wing-body configurations were conducted and are analyzed in the light of the theoretical indications.

Les Détonations Balistiques. G. Chevallier. *Docaéro*, Nov., 1959, pp. 27–30. In French. Discussion of various terms used to define the sonic boom phenomenon, and description of the approach used to study the shape and the propagation of shock waves, as well as the shock intensity.

Acoustically Induced Fatigue—Cause, Solution and Design Analysis. E. W. Thrall, Jr. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 164A.* 23 pp. Discussion of the fatigue problem that developed in the empennage area of the Navy A3D aircraft. Details of ground and flight test programs, the test results, and one effective solution to the cracking problem are presented.

Resonant Fatigue Failures Associated with Noise. R. N. Bingman. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 164B.* 20 pp. 15 refs. Discussion of the extent and diversity of resonant fatigue damage under rapidly fluctuating pressures such as those produced by jet noise. Types of failures, significant noise environments which induce damage, and design criteria and inspection techniques based on experience with USAF weapon systems are surveyed.

Aerodynamics, Fluid Mechanics

Aerothermochemistry, Dissociation, Ablation

A New Concept for Calculating Thermal Boundary Layers. E. W. Adams. *J. Aero/Space Sci.*, July, 1960, pp. 549, 550. Presentation of a calculation to determine the transient distribution at the stagnation point of temperatures and velocity components within an ablation-type heat shield which melts during part of the reentry flight of a ballistic vehicle.

The Melting of Ice in a Hot Humid Stream of Air. D. L. Turcotte. *J. Fluid Mech.*, May, 1960, pp. 123–129. Analysis using appropriate approximations to determine the incompressible stagnation-point ablation rate for ice. The theory includes both melting and vaporization or condensation.

Theory of Equilibrium Electron and Particle Densities Behind Normal and Oblique Hypersonic Shock Waves in Air. C. A. Roberts, W. B. Sisco, and J. M. Fiskin. *IRE Trans., AP Ser.*, Jan., 1960, pp. 102, 103. Application of the aerothermodynamic theory to relate macroscopic properties on both sides of the shock front by means of the flow conservation equations.

Viscous Hypersonic Similitude for a Dissociating Gas. R. J. Whalen. *J. Aero/Space Sci.*, July, 1960, pp. 550, 551. USAF-supported research.

An Experimental and Theoretical Study of Quartz Ablation at the Stagnation Point. M. C. Adams, W. E. Powers, and Steven Georgiev. (*Avco Everett Res. Lab. RR 57*, June, 1959.) *J. Aero/Space Sci.*, July, 1960, pp. 535–543. 11 refs. USAF-sponsored research.

Aerothermodynamics

Vybor Optimal'nogo Rezhima pri Poristom Okhlazhdenii. A. I. Babichev. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 147–149. In Russian. Study covering the selection of the optimum cooling regime for the case of porous cooling of a flat plate in uniform steady flow of gas.

Prediction of Peak Temperature for Satellite Entries with Lift. R. H. Edwards and G. S. Campbell. *ARS J.*, May, 1960, pp. 496–498. Analysis to obtain for given initial conditions at the edge of the atmosphere an accurate estimate of the peak temperature during the first skip of a lifting satellite entry. Lift and drag coefficients are constant, and the flight path angle is assumed small.

Boundary Layer

Entwicklung der Grenzschichttheorie in den letzten drei Jahrzehnten. Hermann Schlichting. (*3rd Lanchester Memorial Lecture, London, Nov. 26, 1959.*) *ZFW*, Apr., 1960, pp. 93–111. 75 refs. In German. Discussion covering the transition from laminar to turbulent flow, boundary-layer control for high lift and low drag of airfoils, aerodynamic heating at high Mach numbers, and boundary-layer effects on swept wings and on rotating bodies

A Theoretical Approach to the Aerodynamically Significant Properties of Roughness from Insects. W. S. Coleman. *Aero. Quart.*, May, 1960, pp. 171–194. Analysis to determine the effective excrescence height downstream of the leading-edge zone. The application of this study in conjunction with a previous analysis regarding the critical conditions for premature transition, leads to estimates of the amount of significant roughness that are in good agreement with flight observation.

A Simplified Method for Estimating the Properties of Thin Aerofoils Influenced by Jet. Svetopolk Pivko. *RAeS J.*, May, 1960, pp. 292–294. Analysis applying a procedure similar to the Glauert treatment of thin airfoils to two general separate cases concerned with the effect of a jet on an airfoil. A simple procedure is proposed for predicting the aerodynamic properties of a thin airfoil provided with a high-velocity jet sheet in its trailing edge.

A Note on the Induced Drag of Jet-Flapped Wings. G. K. Korbacher and K. Sridhar. *RAeS J.*, May, 1960, pp. 290, 291. Discussion of the apparent discrepancy which arises when the change in effective aspect ratio due to blowing, as predicted by the theoretically derived expression for the induced drag coefficient, is compared with that expected from the general flow picture.

Some Instabilities Arising from the Interactions Between Shock Waves and Boundary Layers. N. C. Lambourne. *Gt. Brit., ARC CP 473* (Feb., 1958) 1960. 23 pp. 40 refs. BIS, New York, $0.99. Review of available information concerning the flow fluctuations and instabilities arising from shock-induced separation in the flow over airfoils and wings. The influence this phenomenon has on the oscillatory behavior of airfoils and control surfaces is also briefly discussed. A more detailed consideration is devoted to a recent investigation at the NPL into the part played by shock-induced separation in the instability of a control surface.

Ein Näherungsverfahren zur Berechnung der ebenen und rotationssymmetrischen turbulenten Grenzschicht mit beliebiger Absaugung oder Ausblasung. W. Pechau. (*WGL Jahrestagung, Stuttgart, Oct. 8–11, 1958.*) *DFL Inst. Aero. Bericht No. 117*, 1958. 11 pp. In German. Presentation of a method for calculating the characteristic values of the turbulent boundary layer, based on the approximate solution of momentum and energy equations. The method is applicable for arbitrary continuous distributions of the potential velocity, as well as for the velocities of suction or blowing along the contour.

Control Surfaces

The Determination of Lateral Handling Quality Requirements from Airframe-Human Pilot System Studies. I. L. Ashkenas and D. T. McRuer. *USAF WADC TR 59-135 [AD 212152]*, June, 1959. 80 pp. 57 refs. Presentation of a partial theory of lateral handling qualities. Tentative criteria for certain roll/aileron transfer function quantities are derived and compared with existing pilot opinion data to establish limited regions of validity.

Nedělená Vodorovná Ocasní Plocha. Jindřich Veselý and Vlastimil Pokorný. *Zpravodaj VZLÚ*, No. 2, 1959, pp. 3–10. In Czech. Analysis of the aerodynamic characteristics of an all-movable tail system in terms of longitudinal stability and maneuverability of the aircraft. A survey of the literature covering some flight-test results is presented.

Flow of Fluids

Ob Approksimatsii Uravneniia Reinol'dsa. Ia. M. Kotliar. *AN SSSR Dokl.*, Jan. 1, 1960, pp. 41–44. 10 refs. In Russian. Development of a mathematical approach to hydrodynamic problems, including methods for approximating Reynolds equation encountered in the theory of motion of ideal gases, filtration, and lubrication.

Stability of Inviscid Plane Couette Flow. K. M. Case. *Phys. Fluids*, Mar.-Apr., 1960, pp. 143–148. Derivation of a solution of an initial value problem corresponding to a perturbed inviscid plane Couette flow.

Relativistic Hydrodynamics for a Charged Nonviscous Fluid. Chau-Chin Wei. *Phys. Fluids*, Mar.-Apr., 1960, pp. 323, 324. Analysis showing that the theorems of circulation and vorticity of classical hydrodynamics can be generalized into relativistic charged ones.

Influence Coefficients for Real Gases. M. W. Cardullo. *J. Aero/Space Sci.*, July, 1960, pp. 546, 547. Presentation of influence coefficients similar to those developed by Shapiro, based upon the use of various functions of the compressibility factor (Z). Some of the assumptions made were as follows: (1) the flow is one-dimensional and steady, (2) changes in the stream properties are continuous, and (3) the flow is composed of imperfect gases (both caloric and thermal).

A Line Source on an Interface Between Two Media. V. M. Papadopoulos. *J. Fluid Mech.*, May, 1960, pp. 41–48. USAF-Navy-sponsored analysis to determine the velocity potential of an unsteady line source which lies in a plane separating two media of different density and sound velocity, using the assumption of dynamic similarity.

Les Lois de Similitude dans le Domaine de la Mécanique des Fluides Appliquée à l'Étude des Machines. Ch. Hanocq. *Soc. Ingr. Civ. France Mem.*, Sept.-Dec., 1959, pp. 305–324. In French. Discussion of the laws of similarity in the field of fluid mechanics applied to the calculation of flow machines.

A Note on the Breakdown of Continuity in the Motion of a Compressible Fluid. D. C. Pack. *J. Fluid Mech.*, May, 1960, pp. 103–108. 14 refs. Study considering the relationships holding along the characteristics in an unsteady motion involving plane, axially or spherically symmetrical flow of compressible inviscid fluid. It is shown that the existence of a region of compression anywhere in the flow must lead eventually to the breakdown of continuity. The previous work on this topic is generalized, and some recent numerical calculations in which the expected discontinuity was not found are discussed.

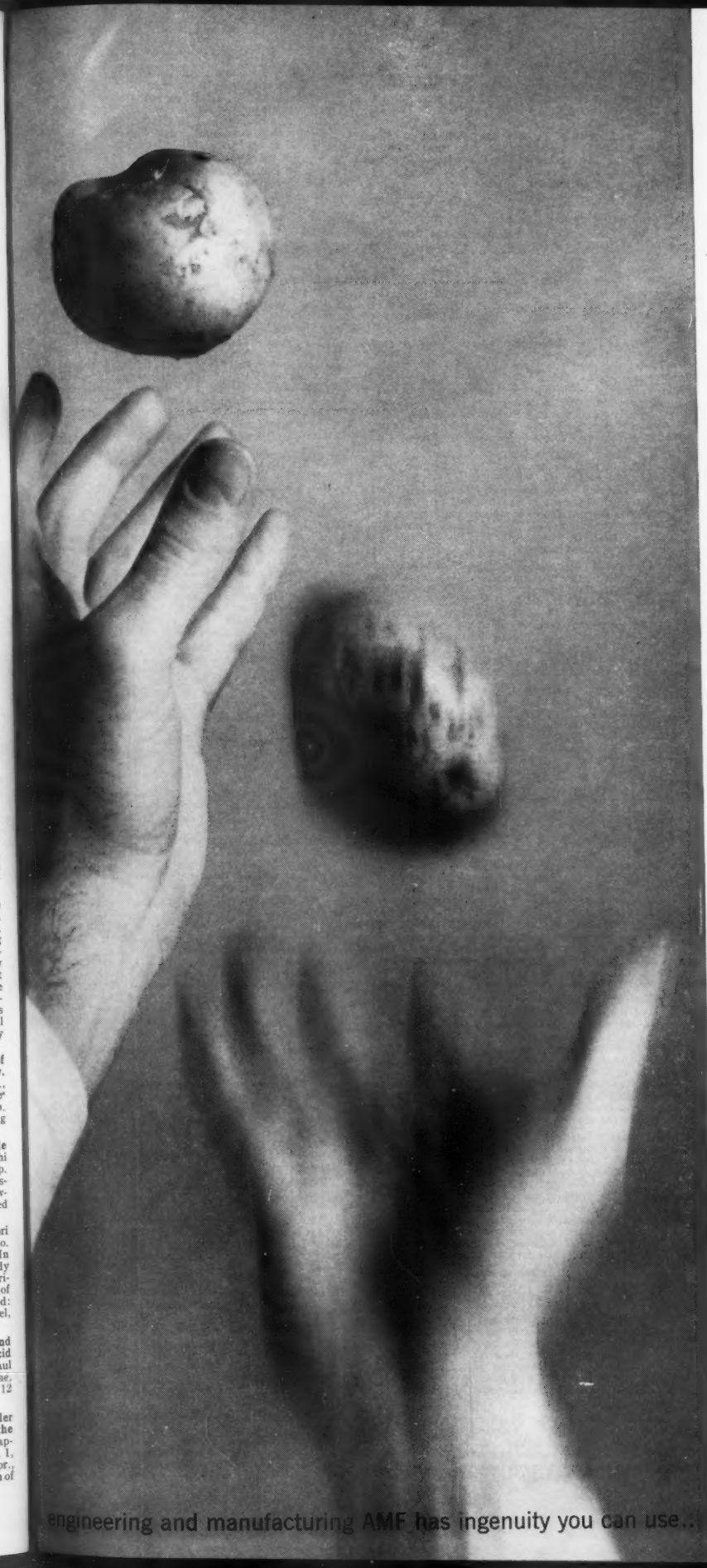
An Approximate Solution of the Problem of Separated Flow Past an Axially Symmetric Body. S. S. Grigorian. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 951–953.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1351–1355. Translation. Presentation of the approximate solution using the theory of "thin bodies."

On the High-Speed Flow of a Compressible Conductive Fluid Past a Slender Body. Ken-ichi Kusukawa. *J. Aero/Space Sci.*, July, 1960, pp. 551–553. Calculation of the flow field and pressure distribution for supersonic flow of a low-conductivity compressible fluid past an insulated slender body.

K Voprosu o Volnovom Soprotivlenii Tela pri ego Krugovom Dvizhenii. E. A. Perzhnianko. *AN SSSR Dokl.*, Jan. 21, 1960, pp. 514–516. In Russian. Calculation of the wave drag of a body moving at constant angular velocity along a horizontal circular trajectory under the free surface of an ideal fluid. Three cases of motion are studied: (a) in a circular tank, (b) in a circular channel, and (c) outside of a circular cylinder.

Numerical Comparison Between Exact and Approximate Theories of Hypersonic Inviscid Flow Past Slender Blunt Nosed Bodies. Saul Feldman. (*Avco Everett Res. Lab. RR 71*, June, 1959.) *ARS J.*, May, 1960, pp. 463–468. 12 refs. Army-sponsored study.

Symmetrical Flow Around a Circular Cylinder with Two Vortices Behind it; Trajectories of the Vortices and Drag of the Cylinder. B. Dolapchiev and B. Sendov. (*AN SSSR Dokl.*, Sept. 1, 1959, pp. 53–56.) *Sov. Phys. - Dokl.*, Mar.-Apr., 1960, pp. 962–965. Translation. Presentation of



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an exact solution to the hydrodynamic problem of a cylinder and a vortex pair in an ideal fluid. The trajectories of the vortices are analyzed, and an interpretation of the formula relating the drag to the position of the vortex pair relative to the cylinder is given.

Inviscid Hypersonic Flow Over Unyawed Circular Cones. L. Pottsepp. *J. Aero/Space Sci.*, July, 1960, pp. 558, 559. Calculation of shock-wave angles, velocity ratios, and pressure coefficients on the surface of the cone for various cone semiapex angles and free-stream Mach numbers.

Hypersonic Shock Wave-Boundary Layer Interaction and Leading Edge Slip. H. T. Nagamatsu and R. E. Sheer, Jr. (*ARS Semi-Annual Meeting, San Diego, June 8–11, 1959, Preprint 855-59.*) *ARS J.*, May, 1960, pp. 454–462. 28 refs. USAF-sponsored research.

On a Singular Point in the Newtonian Theory of Hypersonic Flow. N. C. Freeman. (*Princeton U. Dept. Aero. Eng. Rep. 466*, May, 1959.) *J. Fluid Mech.*, May, 1960, pp. 109–122. 11 refs.

Concerning the Thermal Effect in the Flow of an Electrically Conducting Fluid Between Parallel Walls. S. A. Regirer. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 948–950.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1346–1350. Translation. Investigation of the flow of a viscous electrically conducting fluid in a plane duct in the presence of a magnetic field and heat transfer. The generation of heat from internal friction, Joule heat, and the dependence of viscosity on temperature are taken into account.

O Iavlenii Ezhektsii Elektricheskim Razriadom. B. N. Zhigulev. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 280–283. In Russian. Derivation of the theory on electric discharges in a finitely conducting medium. It is shown that the axisymmetric discharge is followed by the motion of the medium and has an ejecting effect.

Hydromagnetic Effects on Heating and Shear at a Three-Dimensional Stagnation Point in Hypersonic Flow. N. H. Kemp. *J. Aero/Space Sci.*, July, 1960, pp. 553, 554. USAF-supported presentation of a three-dimensional boundary-layer analysis for a constant property fluid in order to estimate the effect of the magnetic field on heat transfer and viscous shear stress.

The Piston Problem in Magnetic Hydrodynamics. G. Ya. Lyubarskii and R. V. Polovin. (*AN SSSR Dokl.*, Oct. 1, 1959, pp. 684–687.) *Sov. Phys. - Dokl.*, Mar.-Apr., 1960, pp. 977–980. 13 refs. Translation. Qualitative investigation of the motion of the fluid in front of the piston moving with constant velocity.

Experimental Dependence of the Collision-Free Shock Thickness Upon Alfvén Mach Number. R. M. Patrick. *Phys. Fluids*, Mar.-Apr., 1960, pp. 321–323. USAF-supported investigation showing the steep dependence of the shock thickness on the shock Alfvén Mach number, M_A, the thickness decreasing with increasing values of M_A. It is concluded that the higher values of M_A correspond to thinner collisionless shocks.

A Certain Class of Exact Solutions of the Equations of Magneto-Gasdynamics. D. V. Sharikadze. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, p. 953.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1356, 1357. Translation.

Magnetohydrodynamics of Weakly Conducting Liquids. S. I. Braginskii. (*Zhurnal Teoret. i Exper. Fiz.*, Nov., 1959, pp. 1417–1430.) *Sov. Phys. - JETP*, May, 1960, pp. 1005–1014. 13 refs. Translation. Presentation of the approximate form of the magnetohydrodynamic equations for a fluid of low electrical conductivity in an external magnetic field. Several characteristic problems which illustrate the physical behavior of such a liquid in a strong magnetic field are examined.

Vliianie Magnitnogo Polia na Ustoichivost' Pogranichnogo Sloia. V. N. Arkhipov. *AN SSSR Dokl.*, Dec. 1, 1959, pp. 751–753. In Russian. Study covering the effect of a magnetic field on the stability of the velocity profile in the boundary layer of incompressible gas along a flat plate.

O Ploskom Techenii Beskonechno Provodiashchei Zhidkosti s Pochti Parallel'nymi Vektorami Magnitnogo Polia i Skorosti. M. N. Kogan. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 284–286. In Russian. Calculation of the boundary layer which forms over the surface of a body in the two-dimensional flow of an ideal, infinitely conducting fluid in the case of almost parallel magnetic field and velocity vectors.

An Asymptotic Approximation Method for a System with Rotating Phases and Its Application to the Motion of a Charged Particle in a Magnetic Field. N. N. Bogolyubov and D. N. Zubarev. (*Ukrainian Math. J*, No. 5, 1955.) *Space Tech. Lab. PRL Paper*, Jan., 1960. 23 pp. Translation.

Losses Through Bremsstrahlung in Relativistic and Ultra-Relativistic Region of Electron Temperatures of Plasma. J. Kvasnica. *Czech. J. Phys., Ser. B*, No. 4, 1960, pp. 261–267.

Motion of a Relativistic Charged Particle in the Magnetic Field Produced by a Constant Cylindrical Current of a Rarefied Plasma. N. I. Shtepa. (*Zhurnal Tekh. Fiz.*, Nov., 1959, pp. 1346–1353.) *Sov. Phys. - Tech. Phys.*, May, 1960, pp. 1237–1243. Translation. Presentation of quadrature relationships which determine the radial dimensions of the region of allowable motion, the period of the radial oscillations, the period of rotation about the axis of symmetry, and the mean drift velocity of the particles in the axial direction.

The Theory of Certain Magnetohydrodynamic Phenomena Occurring in the Free Laminar Thermal Convection of the Electrically Conducting Fluid in a Round Vertical Pipe Located in a Weak Magnetic Field. A. G. Smirnov. (*Zhurnal Tekh. Fiz.*, Oct., 1959, pp. 1245–1251.) *Sov. Phys. - Tech. Phys.*, Apr., 1960, pp. 1141–1147. Translation.

Die Einschliessung eines Plasmas durch ein Magnetfeld. A. Koller. *Raketentech. & Raumfahrtforsch.*, Oct.-Dec., 1959, pp. 109–115. 11 refs. In German. Discussion of various possibilities of containing a plasma within a limited volume by means of electromagnetic forces. Further, a suggestion is made to keep a plasma in a nonstationary state by periodical alteration of the pinch effects.

On the Electrical Behavior of an Ideal Plasma. Giorgio Gambirasio. *Phys. Fluids*, Mar.-Apr., 1960, pp. 299–302. Application of Laplace transforms to obtain solutions for the current in an ideal plasma when the electric field, in a direction perpendicular to a constant magnetic field, is abruptly increased from zero to a constant value. An expression and the corresponding RLC network are found for the specific impedance of the plasma.

Ion-Electron Relaxation of Plasmas in a Magnetic Field. II. Taro Kihara, Yukio Midzuno, Kyoko Sakuma, and Toshio Shizume. *Phys. Soc. Japan J.*, Apr., 1960, pp. 684–687. Analysis considering relaxation between ion and electron temperatures, T_1 and T_2, of dilute fully ionized gases in a magnetic field by the use of a force-correlation method.

Del Flúido Ideal al Plasma—Medio Siglo de Desarrollo de la Aerodinámica. Gregorio Millan. (*Asoc. Nac. Ing. Aero., "Juan de la Cierva" 2nd Annual Conf., Madrid, Oct. 31, 1959.*) *Ing. Aero. & Astron.*, Sept.-Oct., 1959, pp. 1–18. In Spanish. General survey of the development in the field of aerodynamics, covering problems of high-altitude flight, aerothermodynamics, magnetohydrodynamics, and facilities required for simulating environmental conditions.

Priblizhennoe Reshenie Zadachi o Dvizhenii Provodiashchei Plazmy. G. A. Skuridin and K. P. Staniukovich. *AN SSSR Dokl.*, Feb. 21, 1960, pp. 1248–1251. 10 refs. In Russian. Application of an approximate method to the problem involving the integration of equations of plasma oscillation. The case of motion of a gas in a medium of finite conductivity σ is studied.

K Voprosu o Konvektsionnoi Neustoichivosti Plasmy. Iu. A. Tserkovnikov. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 295–298. In Russian. Study of the convective instability of plasma, limited to small-scale perturbations and neglecting boundary conditions.

Stability of Large Amplitude Waves in the One-Dimensional Plasma. David Montgomery. *Phys. Fluids*, Mar.-Apr., 1960, pp. 274–277. Discussion of the stability of the nonlinear plasma oscillations of Bernstein, Greene, and Kruskal. The eigenvalue equation for the perturbed distribution function possesses an expansion in powers of a parameter proportional to the maximum value of the equilibrium electrostatic potential. The stability of any given distribution can be inferred from consideration of the zeroth order alone.

Hydromagnetic Stability of a Streaming Cylindrical Incompressible Plasma. N. J. Zabusky. (*Am. Phys. Soc. Meeting, San Diego, Nov., 1958.*) *Phys. Fluids*, Mar.-Apr., 1960, pp. 278–288. 10 refs. Derivation of a dispersion relation for the case where the equilibrium velocity of an incompressible, nonresistive, cylindrical plasma has a spiral motion along magnetic field lines. The symmetric hydromagnetic equations are used to derive the plasma hydromagnetic pressure.

Nonlinear Oscillations and Nonstationary Flow in a Zero Temperature Plasma. I—Initial and Boundary Value Problems. II—General Characteristics of the Motion. G. Kalman. *Ann. Phys.*, May, 1960, pp. 1–61. 36 refs. Presentation of a transformation for the basic system of equations governing the one-dimensional electrostatic flow and oscillation of a zero-temperature plasma. A closed solution of the general nonlinear problem is achieved and applied to different initial and boundary-value problems.

Oscillations of an Inhomogeneous Plasma in a Magnetic Field. L. I. Rudakov and R. Z. Sagdeev. (*Zhurnal Teoret. i Exper. Fiz.*, Nov., 1959, pp. 1337–1341.) *Sov. Phys. - JETP*, May, 1960, pp. 952–954. Translation. Analysis of a straight pinch with an arbitrary distribution of longitudinal current, considering oscillations at frequencies much higher than the collision frequency but smaller than the ion Larmor frequency. The kinetic equation in the "drift" approximation without the collision integrals is used.

Kinetic Equations for Plasma and Radiation. Albert Simon and E. G. Harris. *Phys. Fluids*, Mar.-Apr., 1960, pp. 245–254. Solution of a chain of equations relating the reduced distribution functions by a generalization of the expansion method of Rosenbluth and Rostoker.

Coherent and Incoherent Radiation from a Plasma. E. G. Harris and Albert Simon. *Phys. Fluids*, Mar.-Apr., 1960, pp. 255–258. Application of previously derived functions giving the probability density in phase space of one of the radiation field oscillators to define an entropy for the electromagnetic field.

The Role of the Radiation from Impurities in the Energy Balance of a Plasma Pinch. V. I. Kogan. (*AN SSSR Dokl.*, Oct. 1, 1959, pp. 702–705.) *Sov. Phys. - Dokl.*, Mar.-Apr., 1960, pp. 1057–1060. Translation. Investigation of the role of the impurity radiation in the energy balance of an actual plasma system contained by the magnetic field of the current flowing through it and heated by Joule heat. Knorr's calculations of the intensity of the radiation (bremsstrahlung, recombination, as well as discrete spectra) as a function of electron temperature are used in the study.

Flow Through Porous Media. A. E. Scheidegger. *Appl. Mech. Rev.*, May, 1960, pp. 313–318. 57 refs. Review of some of the highlights of the physics of flow through porous media. The porous medium is defined; the law of Darcy, mostly used in connection with engineering applications, is discussed; the limitations of Darcy's law, theoretical models of porous media, and displacement processes are then studied.

Bimodal Model for Shock Wave Structure. Charles Muckenfuss. *Phys. Fluids*, Mar.-Apr., 1960, pp. 320, 321. USAF-supported presentation of a theory describing shock thickness and shape of the profile.

Shock-Initiated Detonations. R. A. Strehlow and Arthur Cohen. *Phys. Fluids*, Mar.-Apr., 1960, pp. 319, 320. Investigation of detonation in hydrogen-oxygen and hydrazine systems. Incident and reflected shock wave velocities measured at the back wall indicate that the state of the gas in the reflected shock region corresponds to that of an equilibrium nonreacting system before the adiabatic explosion occurs. Preliminary measurements of the delays to adiabatic explosion in the hydrogen-oxygen system show good agreement with the data of Schott and Kinsey.

Self-Similar Motions of a Gas with Shock Waves, Spreading According to a Power Law Into a Gas at Rest. G. L. Grodzovskii and N. L. Krashchennikova. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 936–939.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1328–1333. Translation. Presentation of the solutions of self-similar motions, which were arrived at on the "Strela" electronic computer. An example covers the practical optimization of body nose shapes in hypersonic flight in terms of the wave drag.

The Heating of a Heat Conducting Wall Behind a Moving Compression Shock. G. A. Tirskii. (*AN SSSR Dokl.*, Oct. 21, 1959, pp. 1140–1143.) *Sov. Phys. - Dokl.*, Mar. - Apr., 1960, pp. 981–984. Translation. Presentation of a solution to the problem of heating of a plane wall in the region behind a plane shock wave moving with a constant velocity parallel to the surface of the wall into a motionless gas.

The Use of Rational Approximation in the Calculation of Flows with Detached Shocks. A. H. Van Tuyl. *J. Aero/Space Sci.*, July, 1960, pp. 559, 560. Study of methods for calculating the body shape which will produce a given axially symmetric bow shock wave. In the present case, the stream function is approximated using certain Padé fractions formed from the Taylor series used by Cabannes. Calculations are carried out in the case of a paraboloidal shock, using paraboloidal coordinates, and the results obtained are in good agreement with other calculations.

Recent Progress in Rarefied Gasdynamics. S. A. Schaaf. (*6th Midwest. Conf. on Fluid Mech., Austin, Sept., 1959.*) *ARS J.*, May, 1960, pp. 443–447. 50 refs. Survey including a discussion of the correct limits for the gas density for continuum flow, some of the various geometries investigated for the slip flow and transition regimes, development in kinetic theory to handle the transition flow regime, and reexamination of free molecular flow theory emphasizing the problem of predicting drag forces on artificial satellites.

Internal Flow

Priblizhennyi Raschet Osesimmetrichnogo Potoka Cherez Nepodvizhnye Reshetki Stupenei s Tsilindricheskimi Granitsami Osevoi Turbomashiny. P. A. Romanenko. *AN SSSR Otd. Tekh. Nauk Izv. Energ. i Avtom.*, Nov.-Dec., 1959, pp. 68–78. In Russian. Development of a method for the approximate calculation of axisymmetric flow through fixed cascades in axial-turbine stages with cylindrical boundaries.

Analiz Rezul'tatov Ispytanii Osevykh Kompressorov Vserezhimnoi Gazoturbinnoi Ustanovki. B. M. Likhterov. *AN SSSR Otd. Tekh. Nauk Izv. Energ. i Avtom.*, Nov.-Dec., 1959, pp. 59–67. In Russian. Analysis of experimental data used to improve methods for the calculation of axial compressors.

Schwingungen in Axialverdichtern. H. Söhngen and A. W. Quick. *DVL Bericht No. 105*, Jan., 1960. 36 pp. 10 refs. Westdeutscher Verlag, Köln & Opladen. In German. Theoretical study of vibrations in axial compressors showing

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INTERNATIONAL AERONAUTICAL ABSTRACTS

A Review of Worldwide Scientific and Technical Literature

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ACOUSTICS, SOUND, NOISE

AN EXPERIMENTAL STUDY OF THE INTERACTION OF STRONG SOUND FIELDS WITH FREE CONVECTION BOUNDARY LAYERS. A. L. Sprott, J. P. Holman, and F. L. Durand. USAF WADC TR 59-717, Nov., 1959. 26 pp. 11 refs. Investigation showing that strong progressive sound fields may interact with a free convection boundary layer on a horizontal cylinder in such a manner as to produce increases in heat transfer rates of the order of 100%. Shadowgraph flow visualization studies indicate that the mechanism of the interaction is such that a separated flow region on the upper side of the cylinder is produced. No effect on the boundary layer or heat transfer is observed until the sound intensity is raised above a certain critical value. In the experiments described, the critical pressure level ranged from 134 to 138 db. In a quantitative analysis of the experimental results, it is postulated that the increase in heat transfer is the result of an interaction of the phenomenom of acoustical streaming with the free convection boundary layer. It is also believed that the mechanism of thermoacoustic transduction may be applicable.

NOTE ON THE BROAD SPECTRUM NOISE OF A JET AND ITS SILENCER. Appendix - JET VELOCITY CALCULATION OF ORENDA DIFFUSER. Sin-I Cheng. GASL TR 149 (AFOSR TN 59-1309), Nov., 1959. 23 pp. Study considering some of the implications of a model given previously for analyzing the broad spectrum noise of a jet when applied to practical systems. Experimental results on the noise reduction by the C.F. 100 Orenda diffuser silencer and by the UTIA Model Ground Muffler are discussed from the points of view of both Lighthill's model and the present model. Based on Lighthill's model, it appears necessary to assume a very large increase of the turbulence intensity accompanying the diffusion of the jet velocity. According to the present model, where the change of the turbulence intensity is neglected, the observed noise reduction or increase is explained by the change of the relative thickness of the shear layer that appears to be of reasonable magnitudes.

AERODYNAMICS, FLUID MECHANICS

Aerothermochemistry, Dissociation, Ablation

DYNAMICS OF A DISSOCIATING GAS. II - QUASI-EQUILIBRIUM TRANSFER THEORY. M. J. Lighthill. J. Fluid Mech., June, 1960, pp. 161-182. 21 refs. Study of quasi-equilibrium theory of transport properties including some details on flows with larger departures from equilibrium. The requirements of quasi-equilibrium are reviewed and the basic equations presented. The effects of momentum transport and energy transport are shown, and the use of diffusivity ratios in simplifying the basic equations is explained. The quasi-equilibrium theory for both convective and radiative heat transfer is then given. An examination is made of the factors governing the dependence of the absorption coefficient α_ν on viscosity, density, and temperature for any diatomic gas, and oxygen is used as a particular example. Finally, the developed formulas are used to predict the radiative heat transfer to the surface of a high-speed projectile flying through oxygen.

Aerothermodynamics

A SOLUTION OF THE COMPRESSIBLE LAMINAR BOUNDARY LAYER EQUATIONS WITH HEAT TRANSFER AND ADVERSE PRESSURE GRADIENT. G. Poots. Quart. J. Mech. & Appl. Math., Feb., 1960, pp. 57-84. 12 refs. Presentation of solutions to the boundary layer equations in which Stewartson's transformation has been applied. A solution is obtained for small X (X being the longitudinal coordinate in the incompressible plane) by means of a power series in terms of X, where the coefficients in the expansion are obtained on integrating a series of ordinary differential equations; for values of X approaching the separation point, the partial differential equations are integrated using standard relaxation methods in conjunction with the Hartree-Womersley method. Dimension-

less quantities related to the shear stress and heat transfer at the wall are evaluated at various stations along the plate from the leading edge to the point of separation.

STAGNATION POINT HEAT TRANSFER RATES AT LOW REYNOLDS NUMBERS. H. Hoshizaki, S. Neice, and K. K. Chan. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-68. Members, $0.50; nonmembers, $1.00. 15 pp. 25 refs. Investigation of the combined effects shock-generated vorticity, surface slip, and temperature jump on heat transfer rates. The incompressible Navier-Stokes equations are considered in the region of the stagnation point of a sphere. Boundary conditions are applied at the surface and immediately behind the bow shock. At the surface, the slip velocity and temperature jump are taken to be proportional to the velocity and temperature gradients, respectively. The inviscid shock relations are used for the boundary conditions behind the shock. The numerical solutions show that the net effect of shock-generated vorticity and the slip boundary conditions is to increase the heat transfer rates considerably over the boundary-layer values for strong shock waves. For weak shocks ($M_\infty < 6$) the heat transfer rates are little changed from the boundary-layer values. An experimental investigation to check the theoretical results was performed in a shock tunnel. Heat transfer rates were measured at the stagnation point of a hemisphere. These heat transfer rates were found to be higher than those predicted by boundary-layer theory and in good agreement with the presented theoretical predictions.

RESEARCH ON THE EFFECTS OF COLLISIONS OF SMALL PARTICLES WITH BODIES MOVING AT HYPERSONIC SPEED. II - EROSION AND HEAT TRANSFER EFFECTS. G. Whitnah, G. Wehner, J. Upton, A. Gaalswyk, W. Torgeson, and D. Rosenberg. USAF WADC TR 58-498, Pt. II, Aug., 1959. 100 pp. 16 refs. Presentation of results for an investigation of heat transfer to smooth and roughened nose cone models. Heat transfer coefficients for models roughened by sandblasting and by etching are compared with those of smooth models for the two stagnation pressures investigated. Large increases in average heat transfer coefficients were found for the roughened models. Locations of maximum heat transfer were measured for both roughened and smooth models and were found to be considerably closer to the stagnation point for the roughened models than for the smooth model. In addition, surface pitting or roughening due to the formation of binary and ternary alloys at elevated temperatures is studied. Recent data on hypervelocity cratering are discussed. Estimates are made of the size and concentration of impinging particles required to produce a surface roughness on a hypersonic body equivalent to that of the etched model investigated.

Boundary Layer

SOME APPROXIMATIONS TO THE SOLUTION TO THE BINARY BOUNDARY-LAYER PROBLEM. E. E. Covert. MIT NSL TR 390 (AFOSR TN 59-1091), Sept., 1959. 23 pp. Analysis considering the binary boundary layer - i.e., a boundary layer with two gas components - in order to find approximate relations between the shear, external velocity, heat transfer, mass transfer, temperature, and concentration of foreign gases. The method used to find these relations closely parallels that of Liepmann, although in some cases Lighthill's technique can be used.

BOUNDARY LAYERS IN THREE DIMENSIONS. J. C. Cooke and M. G. Hall. Gt. Brit., RAE Rep. Aero. 2635, Feb., 1960. 57 pp. 48 refs. Review of recent advances in the theory of three-dimensional boundary layers. In the first part, the boundary layer equations for laminar compressible flow, and the corresponding momentum integral equations, are given in an orthogonal curvilinear system of coordinates. Special forms for streamline and geodesic coordinates are also given. Cross flows are then discussed, and this is followed by an account of an axially symmetric analogy and a compressibility correlation that holds when cross flows are small. In the second part, the exact solutions of Yohner and Hansen are described for the boundary layer having similar solutions or combinations of similar solutions, and of Sedney for the boundary layer on a yawed spinning cone. The third part concerns momentum integral methods in which streamline coordinates are employed. Works by Timman and Hall are described, and are contrasted as examples of extensions to three dimensions of the Pohlhausen and the Thwaites approaches, respectively. The methods of Zaat and Cooke for (laminar) boundary layers with small cross flow are then presented. Finally, an outline is given of methods developed for turbulent boundary layers.

ON THE MACH NUMBER INDEPENDENCE PRINCIPLE FOR A HYPERSONIC BOUNDARY LAYER. N. C. Freeman and S. H. Lam. Princeton U. Dept. Aero. Eng. Rep. 471 (AFOSR TN 59-728), July, 1959. 13 pp. Analysis of the Mach number independence principle for a hypersonic viscous boundary layer as postulated by Hayes and Probstein, considered for the case of a flat plate with no heat transfer. The structure of the boundary layer is given and the transition solution in the neighborhood of the edge of the boundary layer is constructed. This transition layer, in which the boundary layer adjusts to the free stream conditions, is shown to have a thickness proportional to $(M_\infty)^{-1-s}$ as originally suggested (s being the exponent in the viscosity law). The values of density, temperature, and velocity across this layer are determined explicitly in terms of velocity and implicitly as functions of boundary layer coordinates.

THE MOTION OF A THIN OIL SHEET UNDER THE BOUNDARY LAYER ON A BODY. L. C. Squire. Gt. Brit., RAE Rep. Aero. 2636, Feb., 1960. 31 pp. 12 refs. Presentation of solutions pertaining to the interpretation of oil flow patterns for model testing. It is deduced that the oil

flows in the direction of the boundary layer skin-friction, except near separation, where the oil tends to indicate separation too early. The effect of the oil flow on the boundary layer motion is very small. These conclusions are independent of oil viscosity.

O TURBULENTNOM POGRANICHNOM SLOE NESOVERSHENNOGO SZHIMAEMOGO GAZA. I. I. Mezhirov. Prikl. Mat. i Mekh., Jan.-Feb., 1960, pp. 93-99. In Russian. Derivation of equations for the turbulent boundary layer of an imperfect gas - e.g., dissociating air. It is shown that the relations, valid for an ideal gas and obtained only from the equations of motion, continuity, and energy, can be generalized for the case of an imperfect gas by substituting enthalpy for the temperature. Illustrative examples of such relationships are presented. For the problems of heat transfer between the wall and the flow of gas, the generalized Nusselt number applies best; in the absence of heat transfer between the gas and the body, the temperature recovery coefficient should be replaced by that of the enthalpy recovery.

K ISSLEDOVANIIU VOZVRATNYKH TECHENII V OBLASTI OTRYVA TURBULENTNOGO POGRANICHNOGO SLOIA. Iu. A. Dem'ianov and V. N. Shmanenkov. Prikl. Mat. i Mekh., Mar.-Apr., 1960, pp. 237-239. In Russian. Application of the free-turbulence diagram to solve the problem of flows in the region of turbulent boundary-layer separation. The presence of inverse flows in the decelerated regions is taken into account. Considered are cases of supersonic flow about a step (two-dimensional case) and a blunt nosed body equipped with a fixed needle (axisymmetric problem). Previously obtained experimental results indicate that the ratio of the maximum static pressure in the stagnation zone ahead of the step to the pressure in the laminar flow does not vary with the increase in step height if it is more than twice the thickness of the boundary layer. Simultaneously with the increase in step height, the separation point moves upstream of the flow, so that the ratio of the step height to the distance from the step base to the separation point remains approximately constant for the given Mach number of the incident flow. The distribution of the total pressure in different sections of the separation zone indicates the presence of inverse flows in the neighborhood of the wall in the decelerated region, the pressure gradients appearing sufficiently small to be neglected.

Flow of Fluids

A KINETIC THEORY DESCRIPTION OF RAREFIED GAS FLOWS. Appendix A - MAXWELL'S INTEGRAL EQUATIONS OF TRANSFER IN AN ORTHOGONAL CURVILINEAR COORDINATE SYSTEM. Appendix B - CHANGES IN COMPONENTS OF RELATIVE VELOCITY DURING A BINARY COLLISION. Lester Lees. GALCIT HRP Memo. 51, Dec. 15, 1959. 78 pp. 44 refs. Army-supported development of an approach to the kinetic theory of gas flows which starts with Maxwell's original integral equations of transfer, rather than with Maxwell-Boltzmann equation for the velocity distribution function itself. In this procedure, the Maxwell-Boltzmann equation is satisfied in a certain average sense, rather than at every point. The advantage of this method is that relatively simple distribution functions are utilized which contain a small number of unknown functions to be determined by applying the conservation laws, plus several additional higher moments. For simplicity a "two-stream Maxwellian" is employed, which is a natural extension and generalization of Mott-Smith's function for a normal shock, but differs from it in certain essential respects. The method is applied to linearized plane Couette flow and Rayleigh's problem. Reasonable results are obtained for macroscopic quantities such as mean velocity and shear stress over the whole range of densities from free-molecule flow to the Navier-Stokes regime.

EDGE EFFECTS AND THE STABILITY OF PLANE COUETTE FLOW. K. M. Case. Phys. Fluids, May-June, 1960, pp. 432-435. Study of the stability in the case of infinite Reynolds number by considering the initial-value problem appropriate to the linearized Euler equations. The solution is obtained using Laplace transforms with respect to time, Fourier transforms with respect to x, and the Wiener-Hopf technique. The asymptotic behavior of the solutions is investigated, and it is found that the edges have essentially no effect -- i.e., the spectrum of normal modes of the linearized equations is unaltered. Both the Couette flow and the constant shear flow past a semi-infinite plate are stable.

PROSTRANSTVENNYE GIPERZVUKOVYE TECHENIIA GAZA OKOLO TONKIKH TEL PRI BOL'SHIKH UGLAKH ATAKI. V. V. Sychev. Prikl. Mat. i Mekh., Mar.-Apr., 1960, pp. 205-212. In Russian. Investigation of the two-dimensional hypersonic flow about thin bodies. Approximate formulas are derived for calculating the aerodynamic characteristics of bodies at large angles of attack, where the only unknowns are the constants depending upon the cross-sectional shape of the body. The results can be applied to the calculation of aerodynamic characteristics of wings in hypersonic flow under the assumption that in addition to small relative thickness they have very low aspect ratio. The generalization of these results to cover the case of a real gas in thermodynamic equilibrium is considered.

A REVIEW OF MAGNETO-HYDRODYNAMICS. Y. A. Yoler. Boeing Sci. Res. Lab. FSL Rep. 14, D1-82-0027, Oct., 1959. 69 pp. 60 refs. Study of certain problems in magnetohydrodynamics having application in aeronautical, astronautical, and laboratory scale cases. First, the equations of magnetohydrodynamics are briefly discussed, indicating the assumptions involved and emphasizing the distinction between cases where the collisions determine the macroscopic behavior of the fluid and cases where the electromagnetic interactions between charged particles predominate.

This is followed by a brief review of the significance of certain dimensionless quantities and a consideration of the scaling problems. Various problems of flow of a conducting fluid in a channel are treated. Next, the motion of a plasma column between two electrodes, and that of a plasma ring formed by an electrodeless discharge and accelerated by electromagnetic induction are studied. The extension of classical viscous flow problems of Couette flow and Poiseuille flow into magnetohydrodynamics is considered briefly.

A DISCUSSION OF TWO INCOMPRESSIBLE MAGNETOHYDRODYNAMIC FLOWS. III. K. P. Kerney. MIT NSL TR 399 (USAF WADD TR 59-486, Pt. III), Oct., 1959. 52 pp. Presentation of approximate solutions to two problems involving the flow of an incompressible viscous fluid having low electrical conductivity through a transverse magnetic field. The first problem is that of simple pipe flow. It is shown that the effects of the Hall current and ion slip can be incorporated into the continuum solution, to a first order, and that the effects of induced properties are of the order of the magnetic Reynolds number. The second problem involves the Falkner-Skan flow; it is shown that the external magnetic field must be of the order of the square root of the velocity divided by the length for similar solutions to exist. Further analysis shows that, unless the conductivity vanishes outside the boundary layer, the class of magnetic fields required for similar solutions leads to singularities in the external field.

END EFFECTS IN MAGNETOHYDRODYNAMIC CHANNEL FLOW. Frank Fishman. Avco Everett Res. Lab. RR 78 (AFBMD TN 59-5), June, 1959. 14 pp. Analysis of some effects associated with the termination of electrodes and magnetic field in an otherwise uniform magnetohydrodynamic channel flow. Because of end effects, the electrodes may carry more, or less, current than the same length of electrode in the middle of a long channel; this leads to the definition of a length representing the end correction for current. Similarly, a difference in the total force on the working fluid leads to a length representing the end correction for force. These lengths are calculated for various geometries. The electrical efficiency of a channel acting as a generator is computed under the same conditions. It is shown that the end effects decrease generator efficiency least if the magnetic field extends at least one-half a channel height beyond the end of the electrodes.

PLOSKIE TECHENIIA IDEAL'NOGO GAZA S BESKONECHNOI ELEKTROPROVODNOST'IU V MAGNITNOM POLE, NE PARALLEL'NOM SKOROSTI POTOKA. M. N. Kogan. Prikl. Mat. i Mekh., Jan.-Feb., 1960, pp. 100-110. In Russian. Analysis and classification of two-dimensional flows of ideal gas with infinite electric conductivity in a magnetic field. It is shown that in hyperbolic flow past an angular point, the turning of the flow occurs consecutively in two compression shocks or rarefaction waves. The method for calculating these flows is given. The elliptic-hyperbolic flows can be separated into the elliptic region which attenuates at infinity and the hyperbolic region which does not. The flow around bodies with internal currents perpendicular to the flow plane is considered using the case of a plate with zero angle of attack (the conducting layer is assumed to be isolated from the flow) as an illustrative example. In the case of the magnetic field components perpendicular to the flow, the perturbations produced by currents inside the body are not shielded by the flow. In the case of small perpendicular field in the neighborhood of the currents in the ideal infinitely conducting liquid, a magnetic boundary layer is formed.

THE SLOW MOTION OF A MAGNETIZED SPHERE IN A CONDUCTING MEDIUM. J. R. Barthel and P. S. Lykoudis. J. Fluid Mech., June, 1960, pp. 307-314. Analysis considering the case of a moving sphere where the line of the magnetic poles is assumed to be parallel to the direction of the motion of the sphere. The velocity and pressure fields are calculated by two iterations. The distortion of the magnetic field is also calculated. An expression is obtained for the total drag due to viscous, pressure, and magnetic forces.

DVIZHENIE OSESIMMETRICHNOI STRUI GAZA S MALOI PROVODIMOST'IU V OSESIMMETRICHNOM MAGNITNOM POLE. G. M. Bam-Zelikovich. AN SSSR Dokl., Mar. 1, 1960, pp. 47-50. In Russian. Study of the axisymmetric motion of an ideal, compressible conducting gas in an axisymmetric magnetic field. The viscosity and heat conduction of the gas are neglected, and the coefficient of conductivity is assumed to be a constant value. Also assumed are the neutrality of the gas and the absence of the electric field. The hydrodynamic equations are derived in dimensionless form, and the particular case is studied in which, in the absence of the magnetic field, the motion of the gas represents a cylindrical flow with radius r_0 in a space with constant pressure p_∞, the velocity of the flow being constant and equal to V_∞ and the density to ρ_∞. Methods for determining the shape of the flow are indicated.

THE EQUATION OF STATE OF AN IONIZED GAS. II. Appendix A - MATCHING EQUATIONS FOR COEFFICIENTS IN THE APPROXIMATE EXPRESSIONS FOR THE DISTRIBUTION FUNCTIONS. Appendix B - THE FORM OF THE EQUATION OF STATE FOR GASEOUS PLASMA. Appendix C - SECOND ORDER EFFECTS IN THE EQUATION OF STATE. G. K. Bienkowski. MIT NSL TR 398 (USAF WADD TR 59-486, Pt. II), Sept., 1959. 63 pp. 10 refs. Study considering the problem of obtaining the equation of state where coulombic forces can produce appreciable effects. The existing Debye-Huckel approximation as applied to an ionized gas is found to have some limitations as well as theoretical difficulties. The equations which can determine the distribution functions are nonlinear except for asymptotic regions and, therefore, approximate solutions are derived for the nonlinear range with the quan-

tum effects in the ion-electron interactions included. The resulting distributions are used to calculate the equation of state. The relation thus obtained is found to lie near the Debye-Huckel equation of state but closer to the perfect gas relation. Higher order effects resulting from the volume of the particles and attractive forces between the charged and neutral particles are evaluated and found to be at least an order of magnitude smaller than the coulombic effects in the region under consideration.

NEKOTORYE RESHENIIA URAVNENII ODNOMERNOI MAGNITNOI GIDRODINAMIKI I IKH PRILOZHENIIAK K ZADACHAM O RASPROSTRANENII UDARNYKH VOLN. V. P. Korobeinikov and E. V. Riazanov. Prikl. Mat. i Mekh., Jan.-Feb., 1960, pp. 111-120. 15 refs. In Russian. Study covering certain solutions of equations of one-dimensional magnetohydrodynamics and their application to problems of shock wave propagation. Discussed are cases in which equations describing one-dimensional motion of electrically conducting gas with cylindrical and plane symmetry can be integrated. The general solution for the equations of steady motion with infinite conductivity is obtained and a brief description is given of the corresponding flows. Practical applications to the theory of pulse gas discharge are also considered.

THE CALCULATION OF VELOCITY AND TEMPERATURE PROFILES THROUGH A WEAK NORMAL SHOCK WITH AN EXPANSION IN POWERS OF A SHOCK STRENGTH PARAMETER. Martin Sichel. Princeton U. Dept. Aero. Eng. Rep. 488 (AFOSR TN 60-83), Nov., 1959. 60 pp. 17 refs. Solution of the Navier-Stokes equations for the velocity and temperature profiles of weak shock waves ($M_1 \leq 2$). This series, when compared with exact analytical solutions, was found to adequately predict the effects of variable Prandtl number and of variable viscosity. The velocity and temperature are expressed directly as functions of position and shock strength. Also discussed is the effect of Prandtl number and the viscosity-temperature relation on the expansion coefficients. The shock is assumed to occur in a perfect gas with constant specific heats.

AN IMPROVED PERTURBATION THEORY FOR SHOCK WAVES PROPAGATING THROUGH NONUNIFORM REGIONS. M. P. Friedman. J. Fluid Mech., June, 1960, pp. 193-209. USAF-sponsored analysis considering the propagation of a shock wave down a nonuniform tube. Linearized solutions to the problem do not hold when the velocity behind the shock is near or at the sonic speed. By retaining appropriate nonlinear terms of the flow equations, a solution is obtained which holds for all conditions away from sonic. The behavior of supersonic or subsonic flow entering regions of expanding or contracting area changes is discussed. It is found that subsidiary shocks may be formed; these can be located and described using the present solution. Explicit solutions are given for the cases of supersonic or subsonic flow entering a region of linearly expanding or contracting area. The point of shock formation, as well as the path of subsidiary shock, are obtained for the case in which the area contracts.

PRIMENENIE INTEGRAL'NYKH SOOTNOSHENII V ZADACHAKH O RASPROSTRANENII SIL'NYKH UDARNYKH VOLN. G. G. Chernyi. Prikl. Mat. i Mekh., Jan.-Feb., 1960, pp. 121-125. 10 refs. In Russian. Application of integral relationships to problems of the propagation of strong shock waves. Exact and approximate solutions are compared and an equation is derived for calculating the motion generated by the detonation and the expansion of the piston (governed by the power law or occurring at constant speed). The solution of this equation can be used together with the plane cross-sectional law to determine: (a) the shape of the shock wave generated in the hypersonic flow around a profile ($\nu = 1$, plane) and a body of revolution ($\nu = 2$, cylindrical), and (b) the pressure distribution over the surface of these bodies, including the case of a blunt nose.

PASSAGE OF SHOCK WAVES THROUGH DUCTS OF VARIABLE CROSS SECTION. George Rudinger. Phys. Fluids, May-June, 1960, pp. 449-455. Study of a phenomenon in which strong shock waves passing through a duct of variable cross section, approximated by a single discontinuous area change, present a variety of wave patterns. These are unique for particular conditions except for a range of area convergence for which the existence of three solutions was recently shown. Examination of the transient processes that precede the establishment of the final flow suggests, and a general proof confirms, that only one of these solutions can actually be realized if the duct converges monotonically. For more general duct configurations, the other solutions may also be found, but the correct wave pattern may have to be established with the aid of a wave diagram in which area changes are properly taken into account. For configurations with a throat, additional wave patterns may appear both within and outside of the region of ambiguity which then loses its significance.

MEASUREMENTS ON THE BLAST WAVE IN A CONICAL TUBE. W. S. Filler. Phys. Fluids, May-June, 1960, pp. 444-448. 11 refs. Navy-supported study of spherical high-explosive blast waves under simplified laboratory conditions using a sector shock tube and detonating at its apex a high explosive. Pressure-time histories of the shock waves produced in the cone were obtained with pioezoelectric gages. These waves are shown to possess the typical features of spherically expanding blast waves. The magnitude of the peak pressures, positive durations, and impulses of the shock waves are found to be characteristic of those produced by spherical charges of about 60 times the weight of explosives actually used. This falls short of the design amplification of the 22° cone used by about 40%.

SPHERICAL EXPLOSIONS AND IMPLOSIONS. D. W. Boyer. UTIA Rep. 58, Nov., 1959. 116 pp. 22 refs. Investigation of the explosion of 2-in.

diam. glass spheres under high internal pressure. The spheres were initially filled with air or helium at 400 psi and 326 psi, respectively, and were exploded in air at atmospheric pressure. Experiments on the simulation of high-altitude explosions are also reported. Schlieren and spark shadowgraph records of explosion phenomena, and pressure records of the reflection of the spherical shock wave at various radii are presented. An account is given of some initial experiments on the implosion of 5-in. diam. glass spheres. The results were not very satisfactory because of the failure of the spheres to shatter in a desirable manner while under an external pressure of 65 psi. Numerical solutions to the air and helium sphere explosions are described and the experimental wave phenomena are shown to be in good quantitative agreement with the theoretical predictions.

SOME DETAILS OF THE TRANSITION TO TURBULENT FLOW IN POISEUILLE FLOW IN A TUBE. A. M. Kuethe and K. R. Raman. U. Mich. Dept. Aero. & Astron. Eng. Rep. (AFOSR TR 59-84), June, 1959. 31 pp. 13 refs. Presentation of measurements of velocity fluctuations, Reynolds stresses, and shearing stresses at the wall in the transition region of a tube. The measurements are made at a Reynolds number of 6,000 behind three disturbance generators placed in the fully developed laminar flow 620 diameters from the entrance. Results show that the Reynolds stresses and the shearing stress at the wall can reach very high values during the early stages of transition. Implications are discussed regarding possible causes for the high-temperature recovery factor during the transition in high-speed flow over surfaces.

PRIBLIZHENNYI METOD RESHENIIA ZADACH O PLOSKOM VIKHREVOM DVIZHENII GAZA. Iu. S. Zav'ialov. Prikl. Mat. i Mekh., Mar.-Apr., 1960, pp. 228-236. In Russian. Development of an approximate method for solving the problem of two-dimensional vortex flow of gas. Includes application of a previously developed method to the case of adiabatic motion, and generalization of the method of approximations, used to study potential flows, to cover the case of supersonic vortex motion, with derivation of a general approximate solution containing three random functions. A solution is also presented for certain boundary problems involving flows with and without compression shocks.

THE COMPRESSIBLE VISCOUS HEAT-CONDUCTING VORTEX. L. M. Mack. J. Fluid Mech., June, 1960, pp. 284-292. USAF-Army-sponsored development of simple relations for the flow quantities in the irrotational vortex for arbitrary Prandtl numbers. When the Prandtl number is 1/2, the irrotational vortex is also isentropic. When the temperature dependence of the viscosity coefficient is taken into account, the vortex flow is rotational. An exact solution for the rotational vortex is obtained which is suitable for numerical evaluation by successive approximations. Distributions of velocity, temperature, pressure, density, and stagnation temperature through the rotational vortex are given for a typical case.

Internal Flow

ECOULEMENT DE L'AIR A GRANDE VITESSE DANS UN TUYAU DE SECTION CIRCULAIRE. Roger Depassel. France, Min. de l'Air PST 360, 1960. 98 pp. 34 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, NF 14.50. In French. Investigation of the high-speed flow of air in a duct of circular cross section under sensibly adiabatic conditions. In the theoretical study, three successive flow regimes are considered, characterized by (a) the laminar boundary layer involving the extension of the Gruschwitz method, (b) the turbulent boundary layer, and (c) the established flow. The experimental aspects cover a description of the equipment and instrumentation used. The number of sections in which pressure and temperature measurements were made provides a variety of data on the shape and evolution of the velocity profile. Also included is an improvement of the Young and Winterbottom method, as well as a comparison between theory and experimental values.

AN APPROXIMATE THEORY OF AIRFOIL CASCADE IN SUBSONIC FLOW. Goro Kamimoto, Shuji Ishida, and Teruaki Akamatsu. JSME Bul., May, 1960, pp. 177-184. 19 refs. Presentation of a method for calculating subsonic flow past a cascade using the interference technique of the Prandtl-Glauert rule. The results calculated by this method agree well with those obtained by the hodograph method. Moreover, this method may be applied to the inverse problem; the method of calculating the airfoil section of a cascade with the given velocity distribution along the airfoil surface is easily obtained.

SOME SURGE INVESTIGATIONS ON A LOW SPEED COMPRESSOR. Appendix I - BLADE DESIGN DETAILS. Appendix II - NOTE ON THE CALCULATION OF THE PARAMETERS. R. C. Turner and R. A. Burrows. Gt. Brit., NGTE Memo. M.337, Mar., 1960. 31 pp. Summary of some exploratory tests on a low-speed, low pressure ratio, multi-stage axial compressor, in which mismatching is simulated by appropriate staggering of the stages, the last stage alone being unchanged. Overall and stage characteristics, and surge flow coefficients are determined for two degrees of mismatching and for the fully matched condition. In the two mismatched builds, the surge flow coefficients were found to be identical, and were higher than the value for the matched build. The tests indicate that the velocity profile at the last stage may be one significant factor in the determination of the surge point of a compressor.

ON THE SEPARATION PHENOMENON OF BINARY GAS MIXTURE IN AN AXISYMMETRIC JET. Appendix - MASS SPECTROMETER CALIBRATION AND SCATTERING K-VALUE CORRECTION. R. R. Chow. U. Calif. Inst. Eng. Res. TR HE-150-175, Nov. 4, 1959. 68 pp. 14 refs. Presentation of some experimental findings on the

separation of N_2 and 0_2 in an axisymmetric underexpanded jet of air exhausting from a sonic nozzle into a low pressure field of 208 μ Hg. Concentration and pressure fields were obtained through local surveys in the jet. It was found that the jet core was enriched with 0_2. Separation was found increasing downstream; a maximum was observed before the first Mach disc. At various axial stations, radial profiles of the concentration of the 0_2-component produced a minimum value at the location of the diffuse shock barrel inside the jet.

SUR L'ECOULEMENT D'UN JET ENTRE PAROIS. Roger Curtet. France, Min. de l'Air PST 359, 1960. 114 pp. 36 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, NF 29.50. In French. Theoretical and experimental investigation covering the mixing of a jet of incompressible fluid with a surrounding fluid of the same type, taking into account the effect of the mixing chamber walls. Preliminary tests are described; the approximate theory of jets in a confined space is developed and applied to several specific cases, including those of free jets with or without ambient velocity and mixing in a chamber of constant height; experimental results are compared with calculated values leading to the verification of basic hypotheses, definition of the recirculation conditions, determination of various characteristics of mixing expressed in terms of the similarity parameters, and definition of the variation of the friction coefficient along the jet axis. The behavior of the boundary layer at the wall is studied, and the recirculation generated by a jet of revolution in a cylindrical chamber is analyzed.

LAMINAR PARALLEL STREAM MIXING WITH DISSOCIATION AND RECOMBINATION. A. A. Kovitz and R. F. Hoglund. Phys. Fluids, May-June, 1960, pp. 436-443. Application of the boundary layer approximation to obtain closed-form solutions for the approach to equilibrium in a constant velocity mixing zone -- i.e., the velocity gradients are neglected and only temperature and concentration gradients are considered. The chemical system consists of symmetric diatomic molecules and their atoms. A rate of atom production is assumed that is proportional to the difference between local atom concentration and the atom concentration associated with equilibrium mixing. The limiting cases of frozen flow and equilibrium flow appear as special cases of the general solution. Initial composition before mixing zone need not be in local chemical equilibrium. It is shown that nonequilibrium conditions outside the mixing zone can have a strong influence on the evolution toward equilibrium within the mixing zone.

EXPERIMENTELLE UNTERSUCHUNGEN DER GESCHWINDIGKEITSSCHWANKUNGEN IN DER MISCHUNGSZONE EINES FREISTRAHLES NAHE DER DÜSENMÜNDUNG. H. Fabian. DVL Bericht No. 122, May, 1960. 64 pp. 24 refs. Westdeutscher Verlag, Köln & Opladen. In German. Experimental investigation of the velocity fluctuations in the mixing zone of an axially symmetric free jet. Hot-wire measurements were made near the end of the nozzle; the observed periodical fluctuations can be described and classified on the basis of a vortex model. The onset of irregular turbulent fluctuations can be correlated with a critical quantity corresponding to the vortex model. The possibility of correlating periodic velocity fluctuations with a system of ring vortices is also studied, and the experimental results are compared with calculated values for a system of potential ring vortices.

THE IMPINGEMENT OF A SUPERSONIC JET ON A FLAT PLATE. L. F. Henderson. Australia, ARL Mech. Eng. Note 238, Feb., 1960. 18 pp. Presentation of pressure distributions which have been measured with the plate set at various angles to the nozzle axis. At normal incidences, the pressure distribution plotted as a c_p distribution has approximately the shape of the probability curve but includes areas of sub-atmosphere pressure. At lesser incidences, the distribution curves are skewed toward the side of the plate that is nearer the nozzle. In addition, the shock wave system is photographed at three jet Mach numbers.

Wings & Airfoils

A NOTE ON LIFTING LINE THEORY. K. Stewartson. Quart. J. Mech. & Appl. Math., Feb., 1960, pp. 49-56. Calculation of the distribution of circulation around a semi-infinite plane wing of constant chord using the lifting line approximation. The results are used to determine the lift and induced drag of a rectangular plane wing of large aspect ratio.

MINIMUM WING WAVE DRAG WITH VOLUME CONSTRAINT. T. Strand. J. Aerospace Sci., Aug., 1960, pp. 615-619. Development of a numerical method for calculating the minimum thickness drag of supersonic wings having a given total volume. The method is applicable to wings with supersonic leading edges above a certain β AR where $\beta = \sqrt{M^2 - 1}$. The results show that considerable drag reduction is possible by improved volume distribution. The major part of the drag decrease can be obtained by using parabolic arc sections with the maximum spanwise thickness ratio proportional to the local chord variation. Hence, if volume is a criterion, the root thickness ratio of these wings should be much higher relative to the tip thickness ratio than is common practice at subsonic speeds. For wings with sonic and subsonic leading edges, the optimization procedure failed in that negative wing ordinates were indicated over part of the wing.

OPTIMIZATION OF AIRFOILS FOR HYPERSONIC FLIGHT. C. duP. Donaldson and K. E. Gray. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-65. Members, $0.50; nonmembers, $1.00. 18 pp. Analysis concerning the two-dimensional problem of the body shape required for minimum drag when both viscous and pressure drag are considered. The von Kármán momentum integral for boundary layer growth is given in a form which permits an expression for

the local skin friction at a particular point on a body to be derived in terms of an integral which depends on the distribution of body shape up to that point. This expression for the local viscous drag is then combined with the usual expression for the local pressure drag, so that in the case of two-dimensional flow, by a suitable transformation of variables, the expression for the total drag can be put into a form which may be treated by classical methods of the calculus of variations. In addition, methods are discussed for treating the problem subject to the constraint of fixed lift.

AN EXPERIMENTAL INVESTIGATION OF SUPERSONIC WING-BODY INTERFERENCE AND COMPARISON WITH SECOND-ORDER THEORY. Georg Drougge and M. T. Landahl. Sweden, Flygtekniska Försöksanstalten, FFA Rep. AU-II-93:2 (AFOSR TN 60-257), Dec., 1959. 25 pp. Presentation of wind-tunnel experiments on nonlifting cone-cylinder bodies in combination with wings of simple shapes. Pressure distributions are measured at Mach 3 and 4, both around the bodies and on the wings separately, as well as in combination. Comparison is made with second-order solutions obtained previously by using two different theoretical models. An approximate formula common to the two models is derived for the second-order interference terms, and good agreement is found with the experiments.

AEROELASTICITY

A SIMPLE METHOD FOR THE ANALOGUE COMPUTATION OF THE MEAN-SQUARE RESPONSE OF AIRPLANES TO ATMOSPHERIC TURBULENCE. B. Etkin. UTIA TN 32, Jan., 1960. 11 pp. Presentation of a method for calculating the mean square response of an airplane to random atmospheric turbulence, which is given with certain restrictions by the integral of the square of the response to the transient input function Ae^{-rt}. The values of A and r are fixed by the intensity of the turbulence and the ratio of airplane size to turbulence scale. This result is ideally suited to the calculation of mean-square response on analog computers.

THE APPLICATION OF IMPULSIVE EXCITATION TO IN-FLIGHT VIBRATION TESTING. V. L. Beals and S. R. Hurley. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-71. Members, $0.50; nonmembers, $1.00. 19 pp. Description of a reliable technique of impulsive excitation and discussion of the engineering solutions found for early problems encountered by both English and French investigators. The techniques of impulse shaping, rocket motor location, and data analysis are thoroughly described. Data from full scale, transient, in-flight vibration tests of two military aircraft utilizing this technique are compared with theoretical predictions of the subcritical structural frequencies and total system damping.

O ZJAWISKU REZONANSU DLA PÓŁOGRANICZONYCH BELEK SPRĘŻYSTYCH. Józef Więckowski. Rozprawy Inżynierskie, No. 4, 1959, pp. 415-442. In Polish, with summaries in English and Russian. Analysis of forced harmonic steady-state vibrations with zero initial conditions. The characteristics of the reaction forces are determined for various locations of the external force or moment. These characteristics reduce to three coefficients proportional to the displacement, velocity, and acceleration. It is shown that the resonance properties of semi-infinite beams are entirely different from those of finite beams. The phenomenon of the "dynamic obstacle" is described, in which the mechanical energy does not pass across the point where the external force acts for certain frequencies of forced vibration that constitute an infinite sequence.

SELF-EXCITED VIBRATIONS OF A STIFFENED CYLINDRICAL ORTHOTROPIC INELASTIC SHELL IN A LINEARIZED SUPERSONIC FLOW. Z. Dżygadło and S. Kaliski. Vibration Prob. Proc., No. 3, 1960, pp. 3-33. Analysis considering the critical velocities of supersonic flow for an infinite shell characterized by structural and material orthotropy. The structural orthotropy is due to longitudinal and transversal deformable stiffening ribs arranged eccentrically in relation to the shell. The damping properties are also assumed to be orthotropic. In the present study, damping is taken into consideration in the equations and the boundary conditions on the rings and stringers are rigorously satisfied. First, the dynamic equations of anelastic shells with asymmetric reinforcements are derived together with the equations of self-excited vibrations in a supersonic flow. Next, the critical flow velocities are determined, dependent on the damping. Finally, calculations are made for an isotropic anelastic shell with rigid stringers, as well as for one reinforced by deformable ribs, both without rings.

VIBRATIONS OF CONICAL SHELLS. Herbert Saunders, E. J. Wisniewski, and P. R. Paslay. ASA J., June, 1960, pp. 765-772. Analysis using a Rayleigh-Ritz procedure to determine the natural frequencies for a certain class of mode shapes of a thin conical shell built-in on the edge with the smaller radius and either simply supported or free on the other edge. Both bending and extensional energies are included in the analysis. The results show that, for a sufficiently large number of circumferential nodes, the natural frequency predicted by these analyses is very close to the unextensional natural frequency for the same number of circumferential nodes and simply supported at the edge with the smaller radius. The comparison with the inextensional theory predictions is consistent with that already found experimentally - i.e., boundary conditions for this type of shell are not as influential on the higher natural frequencies as the lower ones.

FORCED FLEXURAL VIBRATIONS OF SANDWICH PLATES IN PLANE STRAIN. Yi-Yuan Yu. Polytech. Inst. Bklyn., Dept. Mech. Eng. TN 4 (AFOSR TN 59-567), July, 1959. 22 pp. Application of a new flexural theory of elastic sandwich

plates to the problem of general forced flexural vibration of sandwich plates in the plane-strain case. The classical method of separation of variables combined with the Mindlin-Goodman procedure for treating time-dependent boundary conditions is used. As an example, a solution is given to the problem of a simply supported sandwich plate in plane strain with one of the two end sections prescribing a transverse deflection varying with time.

SIMPLIFIED VIBRATION ANALYSIS OF ELASTIC SANDWICH PLATES. Yi-Yuan Yu. Polytech. Inst. Bklyn., Dept. Mech. Eng. TN 5 (AFOSR TN 59-1082), Aug., 1959. 24 pp. Development of a method of analysis for low frequency range or face plates with very thin faces. Two sets of simple equations of motion are presented. The first set is essentially a special degenerated version of the more complete equations given previously in the one-dimensional form and is introduced as a preliminary to the second set. The second set is then seen as a modification of the first and represents the final equations. The limitations of these equations are next determined by comparing their results for the vibration of the infinite plate with those given by the previous more complete equations. The second set of simpler equations is shown to be subject to less severe limitations and to have better accuracy than the first.

A NEW THEORY OF SANDWICH PLATES - GENERAL CASE. Yi-Yuan Yu. Polytech. Inst. Bklyn., Dept. Mech. Eng. TN 6 (AFOSR TN 59-1163), Nov., 1959. 27 pp. Extension of a previously developed one-dimensional flexural case for vibrations to a general two-dimensional case. Extension as well as flexure are considered, and the core of the sandwich may be either isotropic or orthotropic. As the one-dimensional case, the general theory is valid for any symmetrically arranged three-layered plate and for vibration analysis involving wide frequency ranges. For sandwiches with very thin faces simplified equations good for limited frequency ranges are deduced. A brief discussion is finally given on sandwiches with cores composed of Kelvin-Voigt material.

VIBRATIONS OF ELASTIC SANDWICH CYLINDRICAL SHELLS. Yi-Yuan Yu. Polytech. Inst. Bklyn., Dept. Mech. Eng. TN 7 (AFOSR TN 60-324), Jan., 1960. 32 pp. Extension of a theory for vibration of sandwich plates to the case of cylindrical sandwich shells, from which simplified equations are deduced. On the basis of these equations, axially symmetric and torsional vibrations of the infinite sandwich cylindrical shell are investigated, and numerical examples are presented. Emphasis is placed on obtaining the frequency rather than the phase velocity.

AVIATION & SPACE MEDICINE

HIGH ALTITUDE CHAMBERS AND PRESSURE SUITS AND THEIR PART IN MANNED FLIGHT TO THE MOON. E. W. Still. Brit. Interpl. Soc. J., Mar.-Apr., 1960, pp. 239-276. 20 refs. Study of environmental system engineering to sustain man during all phases of a journey to the moon and back. Current and projected man-bearing vehicles are reviewed, and information from these projects is then used to estimate such parameters as size of cabin, number of crew, duration of flight, and possible heat loads for all stages of the journey. A detailed description is given for a small earth-to-orbit vehicle, a large space station, and a lunar suit. In addition, a mention is made of some possible emergencies and their countermeasures. The conclusion is reached that the environmental engineering for a manned trip to the moon is within existing knowledge, but far projected trips to Mars and other planets will require considerable development of closed-circuit ecology.

ALLOWABLE NUCLEAR REACTOR RADIATIONS FOR A MANNED SPACE STATION IN A COSMIC RAY ENVIRONMENT. David Reitz. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-62. Members, $0.50; nonmembers, $1.00. 27 pp. 32 refs. Presentation of average cosmic ray intensities for a low-altitude orbit as a function of orbital inclination to the plane of the earth's equator, and for paths lying far above the earth's surface. Total allowable nuclear reactor radiation intensities which, when added to the cosmic radiation background, give AEC recommended doses, are given as functions of satellite orbital inclination and exposure time. Sample shield weights are next computed for a specific reactor. The shield weights are those necessary to reduce the reactor radiations to their allowable level at the position of interest. The weight variation upon changing reactor power and distance to the crew position is also presented.

FUELS & LUBRICANTS

COMPILATION OF THERMODYNAMIC PROPERTIES, TRANSPORT PROPERTIES, AND THEORETICAL ROCKET PERFORMANCE OF GASEOUS HYDROGEN. Ch. R. King. US, NASA TN D-275, Apr., 1960. 71 pp. 22 refs. OTS, $2.00. Presentation of data for chamber temperatures from 600° to 5,000°K. and nozzle pressure ratios from 1 to 3,000. Properties and performance parameters include: nozzle-exit pressure, nozzle-exit temperature, enthalpy, molecular weight, isentropic exponent, specific heat at constant pressure, absolute viscosity, thermal conductivity, Mach number, specific impulse in vacuum, ratio of nozzle-exit area to throat area, thrust coefficient, specific impulse, equilibrium gas composition, characteristic velocity, and entropy. Additional data are presented in the form of curves to show some of the properties of normal hydrogen, orthohydrogen, and parahydrogen at low temperatures for several pressures.

BURNING RATES AND IGNITION TEMPERATURES OF HYDROGEN PEROXIDE SOLUTIONS. C. N. Satterfield, E. Kehat, and M. A. T. Mendes. Comb. & Flame, June, 1960, pp. 99-105. Navy-supported study considering the limiting conditions under which decomposition flames can be

ignited and the establishment of the characteristics of such flames, particularly the rate of burning. Mass burning rates were found to agree closely with the flame velocities as measured for the vapor by the Bunsen burner method, when compared at equal adiabatic decomposition temperatures. The limiting combinations of solution concentration and temperature for ignition of flames above hydrogen peroxide solutions are reported to help establish the regions of hazard in handling this material.

CONSIDERATION OF HYDRAZINE DECOMPOSITION. I. J. Eberstein and I. Glassman. Princeton U. Dept. Aero. Eng. Lab. Rep. 490 (AFOSR TN 60-352), Dec. 11, 1959. 23 pp. 23 refs. Presentation of a brief investigation of the molecular structure of hydrazine, and discussion of the catalysis of hydrazine decomposition on metal surfaces. It is found that metals having incomplete d-subshells act as strong catalysts for hydrazine decomposition, whereas metals having no d-subshells, or complete d-subshells act as noncatalysts. Initial steps for hydrazine decomposition under various conditions are proposed and inhibitors for such decomposition are suggested. Inhibitors may be ammonia, aniline, toluene, and xylidene or toluidine. In addition, a brief outline of experimental investigations on hydrazine decomposition is given and compared with the best known previous work on hydrazine.

MECHANICS

THE DYNAMICS OF LARGE ROTATING MEMBRANE-LIKE STRUCTURES. J. G. Simmonds. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-87. Members, $0.50; nonmembers, $1.00. 15 pp. Study of structures which can be used as large, extended controllable antennas; heat collectors; or solar sails for space vehicles. The general equations of motion for an arbitrary rotationally symmetric membrane are derived. An exact analysis of the problem is first made in which all nonlinear terms in the strain-displacement expressions are retained. A physically plausible assumption is then used to simplify these expressions and the final equations are obtained. Some of the inherent difficulties in solving the equations are discussed, and an analysis is made of the simplest, nontrivial case - the flat disc. The linearized in-plane and transverse vibrations are examined in detail and a set of frequency curves is presented. It is shown that at certain rotational speeds the disc becomes elastically unstable. By inference it is concluded that this type of instability would exist in more general membrane configurations than the flat disc and, for relatively small hubs, would limit their maximum rotational speed.

MISSILE, ROCKET, & SPACE TECHNOLOGY

IDEAL PERFORMANCE OF MULTISTAGE ROCKETS. R. D. Geckler. ARS J., June, 1960, pp. 531-536. Presentation of the fundamental performance equations of multistage rockets in graphical forms to show the relationships between motor propellant fraction, size of the total propulsion system in relation to payload, and burnout velocity. The effect of incremental changes in the propellant mass or inert mass of any stage and the effect of an incremental change in the payload on the final burnout velocity are derived in the form of coefficients that allow direct comparison of the relative importance of the characteristics of each stage.

ORBITS FOR PLANETARY SATELLITES FROM DOPPLER DATA ALONE. A. J. Deutsch. ARS J., June, 1960, pp. 536-542. Presentation of a method for defining the orbit of an artificial satellite around another planet. If the satellite carries a suitable transmitter, Doppler observations are capable of giving precise values for the line of sight component of the velocity vector. From such data alone, it is possible to obtain all the orbital elements and the mass of the planet. The analytical apparatus used by astronomers for the discussion of spectroscopic binary stars, adapted to the interpretation of Doppler observations of a planetary or lunar satellite, is described. An example is given of the orbit determination for a satellite of Venus.

THE DESIGN OF INFRARED EQUIPMENT FOR SATELLITE DETECTION. C. F. Borchert. MIT NSL TR 379 (AFCRC TN 60-255), Sept., 1959. 62 pp. Discussion of the problem of observing satellite vehicles with an infrared detector, with emphasis on the design of an optimum ground-based detection system. Near infrared radiation due to the passage of a satellite is assumed. Theoretical considerations for obtaining the maximum signal-to-noise ratio from the detecting element are presented with a preliminary comparison of several methods of attack. Consideration is also given to optical systems with large collector diameters and large fields of view.

Ballistics, Re-Entry

FUNDAMENTALS OF ASTRODYNAMICS. R. M. L. Baker, Jr., and M. W. Makemson. U. Calif. UCLA Astrodynamical Rep. 6 (AFOSR TN 59-1045), Sept. 30, 1959. 336 pp. 139 refs. Survey of those aspects of astrodynamics which have found recent emphasis in the astrodynamicist's efforts to cope with the problems of space vehicle trajectories. The topics discussed include minor planets, comets, astronomical constants, orbit determination and improvement, n-body problem, perturbative techniques, nongravitational forces, observation theory, and applications to interplanetary orbits. Also included is a glossary of technical terms and their definitions.

O DVUKH KLASSAKH PLOSKIKH EKSTREMAL'NYKH DVIZHENII RAKETY V PUSTOTE. Iu. A. Gorelov. Prikl. Mat. i Mekh., Mar.-Apr., 1960, pp. 303-308. In Russian. Study of the conditions governing the extremum (in relation to time and mass consumption) motion of a rocket along a curvilinear trajectory. The rocket is assumed to be an ideally controlled body - i.e., it can instant-

ly assume the required angular orientation in space by turning relative to its longitudinal or lateral axis passing through the center of gravity. This assumption permits the formulation of the problem based only on the power equations of motion and considering the moment equation satisfactory at all times. The motion is analyzed in the active sector of the trajectory - i.e., the mass of the rocket is considered to be variable in time. On the basis of these assumptions, the formulation is made of the problem for determining the characteristics of the (extremum in relation to time) turns of the rocket to a given angle for given initial and terminal velocities, as well as initial and terminal weight of the rocket. The problem of plane motions is solved separately in the horizontal and vertical planes, assuming that there is no effect produced by aerodynamic forces.

OPTIMUM TRAJECTORIES WITH ATMOSPHERIC RESISTANCE. E. W. Graham and B. J. Beane. Douglas Rep. SM-23745, Nov., 1959. 44 pp. Analysis considering the problem of transferring a rocket vehicle from one point to another with minimum fuel expenditure under specified transfer time and terminal velocity vectors. The first case studied is one in which atmospheric resistance is the only external force acting on the vehicle. In the second case, both atmospheric resistance and centrally directed gravitational forces are included. In all cases a translating but nonrotating coordinate system is employed whose origin follows a coasting trajectory between the terminal points. The linearized perturbation force field in this coordinate system is used. Two different methods are employed. One is a method of bounds yielding information which is general, but not complete or precise. In the second method the equations of motion in the moving coordinate system are used, and the results are more precise but not so simple and general in their application.

MANNED RE-ENTRY AT SUPER-SATELLITE SPEEDS. R. B. Hildebrand. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-83. Members, $0.50; nonmembers, $1.00. 11 pp. Study of re-entry techniques over a wide range of design parameters including rocket deceleration, multiple pass entry, and single pass entry. The use of lift is shown to greatly widen the re-entry corridor and to reduce the peak acceleration. Further, the magnitude of the re-entry heating problem is such that ablation materials may offer an attractive solution. Rocket decelerated entry and multiple pass entry each have problems peculiar to their operation, which may make them less desirable than the single pass re-entry. A lifting vehicle with moderate lift-to-drag ratio could be utilized for re-entry with super-satellite velocities and could be protected with ablation materials to overcome the high heating rates associated with the initial entry. As the speed decreases to below satellite speed, where radiation cooling appears attractive, the vehicle could use its lateral maneuverability to provide an extremely flexible system.

Guidance, Control, Stability

PROBLEMS IN ATTITUDE STABILIZATION OF LARGE GUIDED MISSILES. E. D. Geissler. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-63. Members, $0.50; nonmembers, $1.00. 19 pp. 29 refs. Analysis of the control requirements in terms of control torque and angle of attack for a given configuration. The extent to which the control problem can be alleviated by appropriate configuration selection is considered. It is shown that the rigid body control situation is much more favorable for a long slender configuration than it is for a short stubby one. The necessary control deflection in a given wind situation is essentially proportional to the ratio C_1/C_2 of aerodynamic torque per unit angle of attack over control torque per unit control deflection. The selection of very slender configurations is not favorable with respect to structural aspects. Not only do bending torques resulting from wind loads and control action increase with increasing length, but even more undesirable is the reduction in stiffness which goes with growing slenderness ratio. Deformation of the airframes represents a serious hazard to the operation of the control system because it will affect the input to the control system and may easily give rise to unstable oscillations. Another complicating factor arises from the dynamic response of fluid propellants to missile motions which may, under unfavorable circumstances, saturate the control system.

Spacecraft

LONGITUDINAL DYNAMICS OF A LIFTING VEHICLE IN ORBITAL FLIGHT. Appendix - ALTERNATIVE DESCRIPTION OF THE DYNAMIC INSTABILITY. Bernard Etkin. (UTIA Rep. 65, Feb., 1960.) IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-82. Members, $0.50; nonmembers, $1.00. 19 pp. USAF-sponsored analysis of the longitudinal perturbations to the steady orbital flight of a lifting vehicle. The equations are so formulated as to lead to the correct limits at the two extremes - satellite in space and aircraft in the lower atmosphere. Additions to the conventional equations of airplane dynamics are found to be necessary to account for the vertical gradients of gravity and atmospheric density and for the curvature of the undisturbed flight path. Calculations are performed with both linear and nonlinear equations for a particular set of aerodynamic and inertial parameters, and altitudes from 100,000 to 700,000 ft. The linear solutions contain two oscillatory components which can be identified with the classical phugoid and short-period modes, and a new spiral mode which may be unstable or stable, depending on the thrust law. With increasing altitude, the period of the phugoid approaches asymptotically to the time to orbit, and that of the "short"-period mode tends to infinity. In the altitude range of nearly-equal periods there is beating of the two oscillations, producing dynamic instability in pitch. The second-order inertia terms become increasingly important as the aerodynamic terms become negligibly small.

ANALYSIS OF INJECTION SCHEMES FOR OBTAINING A TWENTY-FOUR HOUR ORBIT. Appendix I - LONGITUDE OF THE FIRST NODE AS A FUNCTION OF THE LAUNCHING AZIMUTH. Appendix II - MATHEMATICAL TREATMENT OF DIRECT ASCENT SCHEME. Appendix III - ECONOMY CONSIDERATIONS APPLIED TO LAUNCHING AZIMUTH. Appendix IV - MATHEMATICAL FORMULATION OF LOW-ALTITUDE LOOPING. R. F. Hoelker and Robert Silber. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-75. Members, $0.50; nonmembers, $1.00. 23 pp. Study of some possible schemes that are general and applicable to any desired longitude for the earth-fixed point in the 24-hour orbit. The simpler problem of obtaining the 24-hour orbit without regard to the longitude of the earth-fixed point is first considered. From this, three distinct schemes are developed, each evolving as a correction to the undesirable features of its predecessor. These are: the direct ascent, low-altitude looping, and high-altitude looping.

PARAMETRIC WEIGHT STUDY OF A MANNED SPACE ENTRY VEHICLE. O. A. Kelley, Jr. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-56. Members, $0.50; nonmembers, $1.00. 19 pp. Study showing weight comparison or trend data between different vehicles and heat protection schemes. The gross weight is determined as a function of L/D, wing loading, reference temperature, method of structural cooling, type of mission, and weight of equipment and systems. Configurations with L/D ratios of 0.5, 1.0, and 2.0 are investigated for both satellite and circumlunar missions. The structural cooling methods studied are radiation, ablation, and a combination of radiation plus ablation. The study shows that the weight of minimum sized, three-man vehicles increases with increasing L/D throughout the range studied and for all missions and types of structural cooling studied.

PERFORMANCE AND DESIGN CONSIDERATIONS FOR MANEUVERING SPACE VEHICLES. L. W. Warzecha. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-59. Members, $0.50; nonmembers, $1.00. 15 pp. 10 refs. Analysis to determine the required degree of maneuverability for a variety of space missions, including return to the earth's surface. Design and performance penalties associated with high degrees of maneuverability are presented, with particular attention directed toward near-earth orbital flight. It is concluded that initial space maneuvers will be limited by propulsion requirements, and will consist of rendezvous and intercept in near-earth orbital flight. Vehicle landing or recovery maneuvers will be required for landing at a preselected site from a low altitude orbit on any chosen day, even though the site may be some distance away from the satellite orbital plane. In most practical cases, recovery maneuvers will be performed more economically by semi-ballistic aerodynamic glide than by rocket powered flight. It is also concluded that a modular system for payload and mission flexibility can be achieved without significant weight or performance penalties.

SATELLITE MOTIONS ABOUT AN OBLATE PLANET. M. L. Anthony and G. E. Fosdick. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-57. Members, $0.50; nonmembers, $1.00. 23 pp. 15 refs. Discussion of the drag-free path of a vehicle in the vicinity of an oblate planet. Although the solution found is approximate in the sense that it is a truncated power series in the oblateness parameter, J, there is no restriction on either the eccentricity or the inclination angle. Approximate analytic expressions are derived for the radial position, speed, angular momentum, deviation from the initial plane of motion, and rate of apsidal advance. In addition, the injection speed required for prescribed apses is derived. The differences between first-order results and inverse-square results are found from the analysis, and numerical results are given. A comparison of the analytical results with the results of integrating the equations of motion directly on a digital computer indicates excellent agreement over a wide range of inclination angles and eccentricities.

ON THE PROBLEM OF THE INTERACTION BETWEEN A SATELLITE AND THE EARTH'S MAGNETIC FIELD. Yu. V. Zonov. (Iskusstv. Sputniki Zemli, No. 3, 1959.) US, NASA TT F-37, May, 1960. 11 pp. Translation. Study considering the currents induced by the translational motion of the satellite relative to the magnetic field, then the change in the speed of rotation of the satellite about its own axis due to eddy currents and, finally, the disturbing forces exerted by the magnetic field on a satellite that has no rotation of its own. The most substantial of the foregoing factors is the flow of eddy currents in the metallic hull of the satellite. These currents cause a noticeable reduction in the angular velocity of the satellite about its own axis. The charges and currents due to the translational motion of the satellite do not greatly influence the character of the motion.

PHYSICS

Astrophysics

AERODYNAMIC EFFECTS IN PLANETARY ATMOSPHERES. Zdenek Kopal. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-74. Members, $0.50; nonmembers, $1.00. 9 pp. 34 refs. Discussion of the methods, as well as the results of astronomical investigations of the physical properties of planetary atmospheres - with particular reference to Venus and Mars, the two nearest celestial neighbors - to show the principal differences in their aerodynamic behavior from that of the terrestrial atmosphere. The gaps in the present knowledge of this subject are discussed, and the means by which these gaps can be filled in the near future are outlined.

CRITICAL ANALYSIS OF SOLID DEBRIS IN SPACE. F. C. Jonah. IAS Natl. Summer Meeting Los Angeles, June 28-July 1, 1960, Paper 60-73. Members, $0.50; nonmembers, $1.00. 15 pp. 35 refs. Analysis of a number of physical properties

of solid debris in space that are considered important for the design of space vehicles. The mass, density, and total number of the debris are considered in terms of the best available data on atmospheric properties, IGY meteor observation programs, high altitude rocket probes, satellite impact counts, and various other sources. It is shown that there is a remarkably close agreement between the different estimates of the number of particles within the orbit of the earth when the visual meteor magnitude range from 9 to 30 is considered. An analysis of the density of meteors, based on the generally accepted atmospheric drag, luminosity, and ablation equations, is made.

POWER PLANTS

APPLICATION OF AIR-BREATHING JET ENGINES TO HIGH MACH NUMBER VEHICLES. M. Arens. Aerospace Engrg., Aug., 1960, pp. 26-31, 46. Comparison of air-breathing engines and rockets as to fuel consumption, weight, and speed. The requirements for an air-breathing engine for operation over a wide speed range are studied. It appears that the air-breathing engine, because of its superior fuel consumption, will continue as the optimum power plant for cruising vehicles. For accelerating trajectories, such as satellite launchers and sounding rockets, the air-breathing engine is currently penalized by its poor specific weight characteristics and low speed limit. Some of the developments that would tend to make air-breathing engines competitive with rockets in such applications include: (1) use of turbine entry temperatures above 2,500F. for nonafterburning turbojets; (2) integration of turbojets and ram-jets as combination power plants, with good performance from take-off to hypersonic speeds; and (3) successful application of supersonic burning for ram-jets, with a resultant increase in the engine speed limit. These, in turn, produce development problems in large engine geometry changes required for efficient operation over a wide speed range and cooling of structural components at high speeds.

Jet & Turbine

EXPLORATORY METHODS FOR THE DETERMINATION OF GAS FLOW AND TEMPERATURE PATTERNS IN GAS TURBINE COMBUSTORS. Appendix I - PRINCIPLE AND INHERENT ERRORS OF THE SONIC ORIFICE SUCTION PYROMETER. Appendix II - DEFINITION OF GAS FLOW ASYMMETRY. J. Rosenthal. Australia, ARL Mech. Eng. Note 235, July, 1959. 52 pp. 10 refs. Description of equipment and methods to provide a qualitative and quantitative picture of mean flow distribution, particle history, and heat release. Experience gained in handling the equipment is described, as well as the limitations of the instruments used and the manner in which the choice of measuring grid is governed by the character of the flow system to be examined. These methods have been applied to the examination of a Derwent VIII combustor; they have clearly shown the importance of burning zone whirl in establishing recirculation for flame piloting. The observed decrease of recirculation with heat release is discussed, as well as the secondary effect of fuel spray, and the localized action of atomizer cooling air.

TURBOJET THRUST AUGMENTATION: FLIGHT TEST RESULTS FOR A REHEAT SYSTEM EMPLOYING FUEL INJECTION UPSTREAM OF A TWO-STAGE TURBINE. E. P. Cockshutt, D. F. Daw, G. G. Levy, F. Rueter, and C. R. Sharp. Canada, NRC Aero. Rep. LR-272, Jan., 1960. 51 pp. 12 refs. Presentation of flight results for a thrust augmentation system fitted to an Orenda 14 engine installed in a Sabre 6 aircraft. The reheat system was stable over the range of conditions explored, and operated satisfactorily at the ceiling of the aircraft with a tailpipe static pressure of 3.85 psia. A net thrust boost of 32% was obtained at a flight Mach number of 0.82. Combustion efficiency decreased slowly from 86% at sea level static to 79% at 50,000 ft. With the fixed oversize reheat nozzle, consistent relights were obtained up to 45,000 ft. (corresponding to an altitude of 52,000 ft. with a variable area nozzle in the closed position.) Above 45,000 ft., results were erratic.

Ram-Jet & Pulse-Jet

DETONATION WAVE HYPERSONIC RAMJET. W. H. Sargent and R. A. Gross. ARS J., June, 1960, pp. 543-549. 13 refs. USAF-sponsored study of the performance of a hypersonic ram-jet at flight speeds from Mach 2.5 to 10. Thermodynamic property changes across a detonation wave are presented. Engine cycle performance characteristics are computed including air specific impulse, specific fuel consumption, and thermal efficiency. The effect of component efficiency on cycle performance is examined, and the optimum place in the cycle for the detonation wave is found. The subsonic burning ram-jet is shown to have superior thermodynamic performance compared to a detonation wave engine, but the differences are often minor. Other differences and some design features are discussed.

Rocket

COMBUSTION INSTABILITY IN SOLID ROCKETS USING PROPELLANTS WITH SUSPENDED METALLIC POWDERS. Appendix - ANALYSIS WITH DISTRIBUTED, SENSITIVE HEAT SOURCE MODEL. Sin-I Cheng. Princeton U. Dept. Aero. Eng. Rep. 482 (AFOSR TN 59-1002), Sept., 1959. 32 pp. Analysis of the stability of the acoustic oscillations in the chamber of a solid propellant rocket to reveal the effect of metallic additives to the fuel. The dissipative action of the oscillation of the particles in the condensed phases is neglected. The oxidation of the metallic powders is considered as distributed heat sources to the gas system. The heat addition distorts the acoustic field through the variation of the speed of sound over the chamber volume. This modifies the nondissipative damping action of the supercritical nozzle. The rate of heat release from the metallic powders may fluctuate but lag behind the local gas oscilla-

tion. This oscillatory heat source from the oxidation of the metallic powders, like the oscillatory mass source from the combustion of the basic propellant, can excite unstable oscillations of the gas system. The two exciting forces are, however, out of phase, and may or may not counteract each other.

RESEARCH, RESEARCH FACILITIES

Wind Tunnels

A SURVEY OF HYPERSONIC PROBLEMS AND THE CHARACTERISTICS OF SHOCK-HEATED TUNNELS. A. F. Charwat. ZFW, May, 1960, pp. 125-134. 54 refs. Discussion of the characteristic phenomena of hypersonic aerodynamics in the domain of Mach and Reynolds numbers. Regions of similarity and interactions between these phenomena are schematically defined and used to evaluate the range of application of experimental facilities, in particular, the hypersonic shock tunnel. The principles of operation, and the problems and limitations of shock-heated tunnels are reviewed.

BOUNDARY-LAYER TRANSITION AND HEAT TRANSFER IN SHOCK TUBES. R. A. Hartunian, A. L. Russo, and P. V. Marrone. (Cornell Aero. Lab. Rep. AD-118-A-3, Dec., 1959.) J. Aerospace Sci., Aug., 1960, pp. 587-594. 33 refs. USAF-supported investigation of the wall boundary layer in a shock tube operated over a wide range of shock Mach numbers and pressure levels in air, including those for which real gas effects exist. Transition distances are determined and correlated in terms of the transition Reynolds number based on a characteristic length for this boundary layer. The results indicate a weak dependence of transition Reynolds number on shock strength up to moderate values of shock Mach number, followed by a larger stabilizing tendency. A dependence of transition Reynolds number on the unit Reynolds number is found at the lower shock strengths. Laminar and turbulent flow heat transfer rates to the walls of the shock tube are determined experimentally. The results of the heat transfer measurements substantiate existing theories in both the laminar and turbulent flow regimes.

STRUCTURES

THE CLASSICAL TORSION PROBLEM FOR SECTIONS WITH CURVILINEAR BOUNDARIES. W. A. Bassali. J. Mech. & Phys. Solids, May, 1960, pp. 87-99. 21 refs. Application of complex variable analysis to obtain solutions for the Saint-Venant torsion problem corresponding to certain sections with regular curvilinear boundaries. The area of the cross section is conformally mapped on the unit circle by a transformation involving some parameters. By varying these parameters, various shapes having several axes of symmetry are obtained. Closed and exact expressions are derived for the complex torsion function, the torsional rigidity, and the shearing stresses at any point of the section. The distribution of shearing stress on the boundary is investigated in the general case, and graphs showing its variation in four particular examples are plotted.

Beams & Columns

PLASTIC FLEXURE AND TORSION. E. O. Imegwu. J. Mech. & Phys. Solids, May, 1960, pp. 141-146. Analysis considering the plastic flexure and torsion of prismatic beams loaded by terminal bending and twisting moments which, acting together, cause full plastic flow. The material is assumed to behave according to the Tresca-Lévy-Mises hypotheses, and is nonhardening and rigid plastic. The results are obtained by numerical solution of the second-order nonlinear differential equation derived by Handelman for a Lévy-Mises material, and the beam sections investigated are circular, square, and triangular. The relationships obtained are found to give points lying virtually on a single interaction curve plotted with nondimensional coordinates. The results are consistent with the two cases considered by Steele, first reporting a numerical solution for a square section. The interaction curve obtained is compared with the lower bound curve given by Hill and Siebel.

A GENERAL THEORY OF INELASTIC COLUMN FAILURE. I, II. R. Hill and M. J. Sewell. J. Mech. & Phys. Solids, May, 1960, pp. 105-118. Application of a continuum theory of uniqueness for general inelastic solids to the basic column problem. A critical condition for bifurcation is obtained, generalizing and correcting the Shanley tangent-modulus formula. General sufficient conditions are formulated, respectively, for either dynamic stability of instability under dead loading. These indicate a criterion of stability, and the corresponding critical load is calculated for a built-in column under compression. This load is found to lie above the bifurcation (Shanley) value, and coincide with the reduced modulus (Engesser-Karman) value modified to allow for the effect of shear deformation.

Cylinders & Shells

THE THIN-WALLED CIRCULAR CYLINDER SUBJECTED TO CNCENTRATED RADIAL LOADS. L. S. D. Morley. Quart. J. Mech. & Appl. Math., Feb., 1960, pp. 24-37. 11 refs. Application of a previously developed equation governing the radial displacement of a thin-walled circular cylinder to obtain expressions for this displacement and the resultants in an infinitely long cylinder subjected to equal and opposite concentrated radial loads. In addition, a method of numerical approximation is presented which enables the calculations to be carried out with rapidity and yet retaining an accuracy usually associated with Flügge's equations.

THE DESIGN IMPLICATIONS OF CREEP IN PRESSURIZED CYLINDRICAL SHELLS. Ivan Rattinger and Joseph Padlog. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-70. Members, $0.50; nonmembers, $1.00. 27 pp. 43 refs. USAF-sponsored presentation of a method for

estimating the creep deformations and the time to failure of cylindrical shells operating at elevated temperature under constant applied pressure. This method is keyed to the uniaxial tensile creep strength of the materials considered. Test-theory comparisons are then made to establish the validity of the solution technique. Estimates of the biaxial creep strength of materials for which no published data are available are then set forth. The complexities introduced by time varying stresses and temperatures are next hypothesized, and the applicability of the solution obtained is discussed. Finally, certain conclusions are drawn, and recommendations for future analysis and experiment are presented.

THERMO-ELASTIC EQUATIONS APPLICABLE TO THICK-WALL, POINTED SHELLS OF REVOLUTION. Appendix - DERIVATION OF STRESS FUNCTION EQUATION IN CYLINDRICAL COORDINATES. R. D. Sutherland and R. G. Shook. Convair TM 349-14 (AFOSR TN 59-1274), Nov., 1959. 29 pp. Presentation of thermo-elastic equations necessary to define the stress distribution in a thick-walled, pointed shell of revolution. A coordinate system, based on the classic ogive shape which is applicable to a variety of low drag aerodynamic shapes, is utilized in the analysis. Stress functions equations are derived in these ogive coordinates. Techniques are presented for use at the boundaries of the shells of revolution and at the axis of revolution. The equations presented can be solved by numerical methods and are a basis for further work in obtaining analytical solutions to the stresses in a thick wall, pointed shell of revolution.

SANDWICH CYLINDERS. I - STATE OF THE ART AND ADVANTAGES OF SANDWICH CONSTRUCTION. M. I. Kazimi. Aerospace Engrg., Aug., 1960, pp. 32-37, 46. 18 refs. Comparison of sandwich cylinders with various conventional types of cylindrical construction for reliability and efficiency under several types of loading. The growth and nature of fatigue failures are discussed and correlated with hoop stress and stiffening ratio when using honeycomb as a core. Improved results are obtained with honeycomb construction in structures exposed to vibration and shock.

Fatigue

THE FAILING STRESS ON MUSTANG WINGS WEAKENED BY FATIGUE CRACKS. A. O. Payne and N. L. Squire. Australia, ARL S&M Note 259, Oct., 1959. 14 pp. Investigation showing that the normal design analysis, applied to the cracked section, considerably overestimates the actual strength. The average value of the stress at failure for a total of six cracked specimens is 40,600 psi. This is much lower than the ultimate tensile stress or even the allowable design stress of the material.

Plates

DEFLECTION AND STRESS PATTERNS IN PLATE-TYPE STRUCTURES, THEORY VERSUS TEST RESULTS. Appendix A - RIGOROUS TREATMENT OF THE DERIVATION OF THE MATRIX DEFLECTION EQUATION. Appendix B - RIGOROUS TREATMENT OF THE DERIVATION OF THE MATRIX MOMENT EQUATION. N. J. Hess. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-86. Members, $0.50; nonmembers, $1.00. 19 pp. Analysis of the deflection and stress distribution of a plate-type structure with variable stiffness, loading, and boundary conditions, applicable to the determination of the deflected shape of an airfoil surface under aerodynamic loading. The basic assumption for the approximation of the rigorous theory involves idealizing the deflections. The chordwise deflection at any spanwise station is expressed in the form of a parabolic equation, where the coefficients are unknown functions of the spanwise stations. By utilizing the idealization, each spanwise station has three degrees of freedom that must be determined; these can be programed on a digital computer. Application is made to full-depth honeycomb construction for airfoil surfaces attached to the side of a shell-type structure with full and partial root support. An experimental test program was established for such a structure, and a comparison is made between the results.

PEWNE ZAGADNIENIE TERMOSPRĘŻYSTE DLA ORTOTROPOWEJ TARCZY PROSTOKĄTNEJ. Piotr Wilde. Rozprawy Inżynierskie, No. 4, 1959, pp. 557-569. In Polish, with summaries in English and Russian. Analysis to determine the thermal stresses in a rectangular plate whose edges are free from stresses. It is assumed that the plate is both elastically and thermally orthotropic. The temperature at the edges is known and distributed in an arbitrary manner. It is assumed that the heat flows across the surface of the plate at a rate proportional to the temperature difference between the plate and the ambient medium, at the point considered.

ON THE BUCKLING OF AN ANNULAR PLATE. E. H. Mansfield. Quart. J. Mech. & Appl. Math., Feb., 1960, pp. 16-23. Analysis considering the buckling of an annular plate in which the radial and hoop stresses vary inversely as the square of the distance from the center. The presence of diametral nodal lines, either imposed or occurring naturally, is allowed for, and this enables the buckling behavior under tensile, as well as compressive, radial stresses to be determined. Figures are presented giving the buckling stress as a function of the geometrical proportions of the plate for a variety of boundary conditions.

PROPAGATION OF THERMOELASTIC WAVES IN PLATES. Witold Nowacki and Marek Sokołowski. Arch. Mech. Stosowanej, No. 6, 1959, pp. 715-727. Study covering the problem of propagation of plane waves in elastic plates, taking into account the coupling of the equations of motion and heat transfer in the form given by Biot. The effect of this coupling on the character of wave propagation is studied for two extremum cases: a very

thick plate or a very thin plate in relation to the wave length. This effect is reflected by the increase in the phase velocity of the wave motion and by the appearance of dispersion producing terms in the solutions for the displacement.

Plates with Holes

ON SOME PLANE PROBLEMS OF AN INFINITE PLATE CONTAINING AN INFINITE ROW OF CIRCULAR HOLES. Makoto Isida. JSME Bul., May, 1960, pp. 259-265. Analysis considering a plate with the following types of loading: uniform tension, tension in an arbitrary direction, uniform shear, bending, uniform internal pressure, and cosine-type and sine-type internal pressures. Formulas for the circumferential stress are given in the form of power series and the numerical results are examined.

Thermal Stress

THERMAL STRESSING DUE TO AN ARBITRARY HEAT SOURCE IN A CIRCULAR CUTOUT. G. R. Cowper. Canada, NRC Mech. Eng. Rep. MS-101, Mar., 1960. 22 pp. Presentation of formulas for thermal stresses and displacements in a circular elastic plate with a concentric circular cutout due to an arbitrary but steady heat input at the edges of the plate. Formulas for thermal stresses in an infinite plate with a single circular cutout are obtained as a limiting case.' Numerical results are worked out for the case in which an arbitrary arc of the edge of the cutout is held at a high temperature while the remainder of the edge remains cool.

THERMODYNAMICS

AN EXPERIMENTAL STUDY OF VORTEX CHAMBER FLOW. J. P. Holman and G. D. Moore. USAF WADC TN 59-388, Oct., 1959. 28 pp. Experimental and analytical investigation showing that a relatively simple analysis predicts the functional variation of temperature and pressure in a vortex chamber with radius and inlet velocity. The predicted variation is in good agreement with experimental observations. By assuming that the flow outside of the chamber occupies some effective flow area, which is essentially independent of flow rate, the inlet velocity may be expressed in terms of the chamber dimensions and the fluid properties at entrance. The effective flow area assumption is verified experimentally for two chamber exit configurations using air.

Combustion

THE THEORY OF A SPHERICAL PREMIXED LAMINAR FLAME. A. A. Westenberg and S. Favin. Comb. & Flame, June, 1960, pp. 161-171. 15 refs. Navy-supported presentation of the general equations governing the behavior of a low velocity, steady state, premixed, laminar flame given for the case of spherical symmetry, showing the differences from the plane flame. Numerical solutions for the simple A → B flame with Lewis number of unity are discussed. The definition of burning velocity is discussed, and its dependence on radius of curvature is clearly shown by the results. The relation between flameholder heat loss and stability is examined in the light of a recent discovery by Hirschfelder. The advantages of the spherical flame for flame structure studies are described.

THEORETICAL CALCULATIONS IN GASEOUS DETONATION. C. L. Eisen, R. A. Gross, and T. J. Rivlin. Comb. & Flame, June, 1960, pp. 137-147. 14 refs. USAF-supported calculation of the combustion properties of a five-atom system (C, H, O, N, A) in one-dimensional steady flow for a Mach number range from 0 to 10, where the products of combustion are in thermodynamic equilibrium. The equations and methods of solution are set forth. Equilibrium and frozen sound speeds are calculated for the hot product mixtures. The effect of initial conditions and comparisons with experiment are given.

Heat Transfer

DETERMINATION OF THERMAL RADIATION INCIDENT UPON THE SURFACES OF AN EARTH SATELLITE IN AN ELLIPTICAL ORBIT. A. J. Katz. IAS Natl. Summer Meeting, Los Angeles, June 28-July 1, 1960, Paper 60-58. Members, $0.50; nonmembers, $1.00. 15 pp. Presentation of a procedure for determining the radiation incident on a satellite in an elliptical orbit. The satellite is treated as a set of plane areas, each area identified by the direction cosines of its outward normal with respect to a "satellite coordinate system." This system is based on orbit orientation. Radiation emitted and reflected by the parent body is computed by integrating over the spherical cap "seen" by the satellite. Solar radiation is considered constant. The method is applied to a hypothetical satellite in orbit. Comparisons of incident radiation are made between rotating and nonrotating satellites in the same orbit. Generalized curves are given, from which preliminary design information can be obtained for any satellite.

VTOL & STOL

POWERPLANTS FOR VTOL AIRCRAFT: A PROPOSED DUAL-OPERATION SYSTEM USING WING-IMMERSED FANS FOR VERTICAL THRUST. E. P. Cockshutt and N. Galitzine. Canada, NRC Aero. Rep. LR-265, Oct., 1959. 90 pp. Presentation of calculated performance and weight data for a category of VTOL power plants in which highly loaded fans (500 lb./ft.^{2}), immersed in the wings, are used to augment the hovering thrust of conventional turbojet engines. The augmentation ratio, shown to be on the order of 3.5, implies a satisfactory matching of the cruising and hovering capabilities of the power plant for high-altitude flight, but a surplus of cruising thrust is produced for short low-altitude missions. Operation with oversize propelling nozzles in the cruising configuration appears to offer a modest improvement in the fuel consumption at the expense of generally unneeded available thrust. The computed weights indicate the desirability of employing several small fans and gas generators rather than one or two large ones.

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the considerable importance of the compressibility of flowing medium at low flow velocities in the presence of blade vibrations.

Gas Flow Through an Opening in a Channel Wall. V. I. Troshin. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 944–947.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1340–1345. Translation. Presentation of the solution for the problem of gas flow through an opening in one of the parallel walls of a channel. The solution yields, as a limiting case, a solution to the problem of the efflux of gas through a hole in the plane parallel to its direction of flow.

On Unsteady Gas Flows in Laval Nozzles. O. S. Ryzhov and G. M. Shefter. (*AN SSSR Dokl.*, Sept. 21, 1959, pp. 485–487.) *Sov. Phys.-Dokl.*, Mar.-Apr., 1960, pp. 939–942. Translation. Analysis of unsteady, nearly sonic flows, changing rapidly with time. These flows are described by the wave equation of acoustics.

Novye Soplovye Apparaty dlia Sverkhzvukovyk Skorostei. M. E. Deich, A. E. Zarfankin, and A. N. Sherstiuk. *Teploenergetika*, Nov., 1959, pp. 65–68. In Russian. Survey of geometric characteristics and results of profile tests on nozzles for supersonic velocities.

Jet Flows with Shocks. M. M. Moe and B. A. Troesch. *ARS J.*, May, 1960, pp. 487–489. Calculation of the flow field including shocks of an axially symmetric supersonic jet expanding from a nozzle. The method of characteristics supplemented by the Rankine-Hugoniot relations for the shocks inside the jet flow and in the surrounding air are used for the computations.

Dynamics of the Turbulent Free Jet. P. D. Sunavala. *J. Sci. & Ind. Res., Sect. B*, Feb., 1960, pp. 35–45. Presentation of a general free jet equation derived from compressible fluid flow theory which, in conjunction with data on thrust measurements, makes possible the deduction of the axial decay curve for any jet operating at any nozzle pressure and exit temperature in the subsonic range. A new technique of measuring burner thrusts, based on the rotating fountain principle, is also discussed.

Priblizhennoe Postroenie Odnogo Klassa Nestatsionarnykh Okolozvukovykh Techenii. O. S. Ryzhov and G. M. Shefter. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 276–279. 13 refs. In Russian. Derivation of an exact partial solution for the equation describing the potential flows without density jumps which contain local supersonic zones varying with time. The case of a gas moving in the neighborhood of the critical section of a Laval nozzle having two planes of symmetry is considered.

Fluorescent Technique for Determining the Cross-Sectional Drop Size Distributions of Liquid Sprays. G. M. Benson, M. M. El-Wakil, P. S. Myers, and O. A. Uyehara. (*ARS 13th Annual Meeting, New York, Nov. 17–21, 1958.*) *ARS J.*, May, 1960, pp. 447–454. 12 refs. Description of a technique consisting of focusing a short-duration, high-intensity radiation flash into a thin sheet of radiation which intersects the spray nearly perpendicularly to the spray axis. The spray drops within this sheet, acting as primary radiators due to a fluorescent die additive, are photographed and subsequently measured.

Jet Flaps & Wings

Application du Soufflage au Bord de Fuite au Contrôle de la Déflexion des Grilles d'Aubes. J. Paulon. *La Recherche Aéronautique*, Nov.-Dec., 1959, pp. 17–20. In French. Description of wind-tunnel experiments made to study the application of trailing edge blowing to cascades in order to control the deflection of blades.

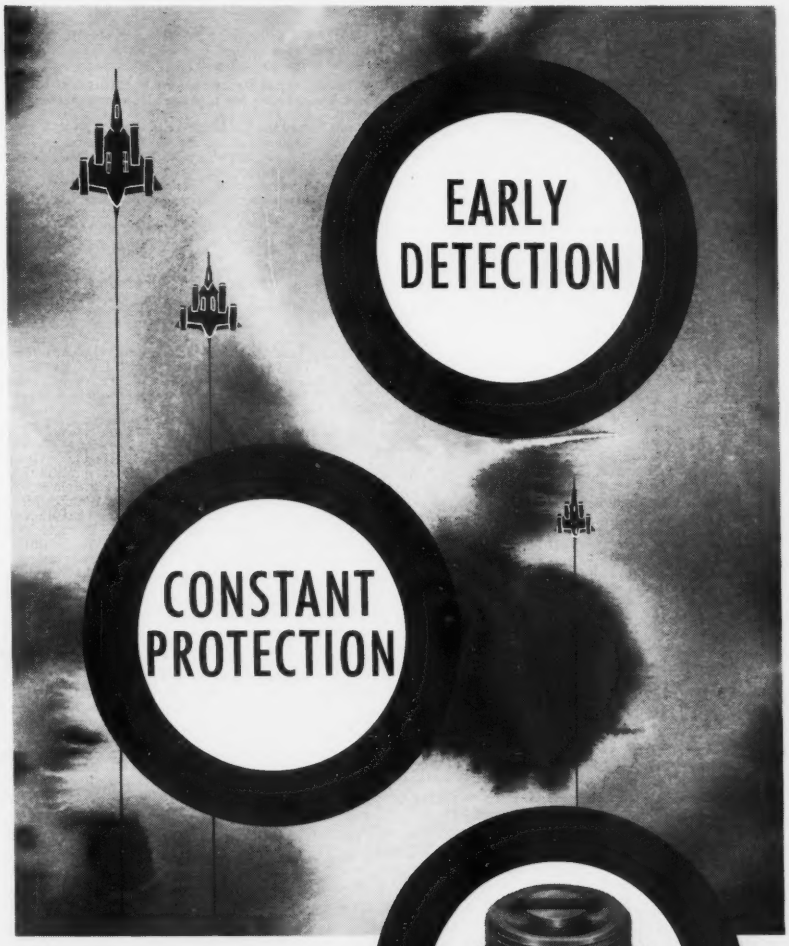
Wings & Airfoils

On Supersonic Flow Past Thick Airfoils. Abraham Kogan. (*Technion Res. Devel. Found., Haifa, Final Rep.*, Feb., 1959.) *J. Aero/Space Sci.*, July, 1960, pp. 504, 508, 516. USAF-sponsored study of the inviscid rotational supersonic flow behind the shock wave attached to the sharp leading edge of a 10 per cent thick parabolic biconvex airfoil.

Tragflügeltheorie bei Unterschallgeschwindigkeit. K. Gersten. (*WGL Jahrbuch, 1958.*) *DFL Inst. Aero. Bericht No. 115*, 1958. 16 pp. 64 refs. In German. Survey of work done in the field of wing theory for incompressible stationary flow. Extensions of established methods and comparisons between theoretical and experimental results are studied, emphasizing problems of ring airfoils, jet flaps, and nonlinear effects in wings.

An Investigation of the Flow Over a Half-Wing Model with 60.5 Degree Leading Edge Sweepback at a High Subsonic and Supersonic Speeds. F. O'Hara and J. B. Scott-Wilson. *Gt. Brit., ARC CP 471* (Nov., 1955) 1960. 58 pp. 14 refs. BIS, New York, $1.44. Presentation of pressure measurements and surface oil flow observations made in the NAE 3-ft. tunnel on a half-wing model. A physical picture of the flow characteristics at high subsonic speeds is suggested. At supersonic speeds, the main feature is the development of a shock wave on the wing, extending inward from the tip region as incidence is increased.

Drag Reduction of Thin Wings at Supersonic Speeds, by the Use of Camber and Twist. G. M.



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Roper. *Gt. Brit., ARC R&M 3132* (July, 1957) 1959. 79 pp. 43 refs. BIS, New York, $4.95. Study of drag reduction showing that twist, especially toward the wing tips, is more effective in reducing drag for given lift at the larger values of tan γ/tan μ, where γ is the semiapex-angle and μ is the Mach angle; and that camber is more effective for the smaller values.

High-Frequency Oscillation of Slender Bodies and Wings. Meir Hanin. *J. Aero/Space Sci.*, July, 1960, pp. 544, 545. Derivation of the velocity potential and pressure along the surface of an oscillating body.

The Effect of Fuselage Modifications on the Zero-Lift Transonic Drag of a Fighter Aircraft (Hunter F. Mk. I) as Measured by Free-Flight Model Tests. G. H. Greenwood. *Gt. Brit., ARC CP 482* (Sept., 1958) 1960. 18 pp. BIS, New York, $0.54. Investigation showing that the greatest drag reduction can be realized by a complete fairing according to the sonic area rule.

Aeroelasticity

Prediction of Flexibility and Natural Modes of Low Aspect Ratio Wings Using Stiffness Matrices. R. J. Melosh and R. G. Merritt. *Aero/Space Engrg.*, July, 1960, pp. 25–31, 45. Presentation of an analysis of complex wing structures, using previously developed stiffness matrices. Measured and analytical results are compared.

O Postroenii Obshchego Resheniia Dinamicheskoi Zadachi Teorii Uprugosti dlia Poluprostranstva v Sluchae Osevoi Simmetrii. N. M. Borodachev. *Iasi Politeh. Inst. Bul.*, Fasc. 3–4, 1958, pp. 85–88. In Russian. Presentation of a general solution for the problem of unsteady oscillations of an elastic half-space in the case of axial symmetry, based on the method of integral transformations.

The Effect of a Damping Compound on Jet-Efflux Excited Vibrations. II—The Reduction of Vibration and Stress Level Due to the Compound. D. J. Mead. *Aircraft Eng.*, Apr., 1960, pp. 106–113. Discussion of the modes of fuselage vibration that could be excited by jet-efflux pressure fields, and of the initial acoustic and structural damping of the modes. A simplified theory is presented for the acoustic damping of flat panels set in a much larger body, such as a fuselage.

Prediction of Aircraft Wing Gust Fatigue Damage by Means of Power Spectral Analysis and Constant Life Curves. R. H. Games. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 108W.* 17 pp. 18 refs. Outline of a method of power spectral solution which predicts aircraft wing experience in terms of oscillatory bending moment. A method of developing representation of wing fatigue characteristics in the form of constant life curves is discussed. An illustrative example of predicting gust fatigue damage is included.

Chastoty Sobstvennykh Kolebanii Osnovnogo Tipa Kol'tsevykh Plastinok s Tsilindricheskoi Anizotropiei. N. K. Pesennikova and I. E. Sakharov. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 134–136. In Russian. Determination of the frequency of natural vibrations for the case of annular plates with cylindrical anisotropy. The two sets of boundary conditions considered are specified, and the Bubnov-Galerkin method is used in the calculation.

Simplified Vibration Analysis. V—Combination of Subsystems. VI—Beams. A. H. Church. *Mach. Des.*, Apr. 14; 28, 1960, pp. 179–184; 141–150. 27 refs. Presentation of methods for handling coupled systems, determining natural frequencies of complex systems, and evaluating the effect of support flexibility on natural frequency. In addition, two simplified beam analysis methods based on mobility techniques are given.

Simplified Vibration Analysis. VII—Frames, Structures, and Spring-Mounted Beams. A. H. Church. *Mach. Des.*, May 26, 1960, pp. 135–142. 10 refs. Presentation of receptance and displacement-mobility methods for analyzing steady-state vibration of frames or structures. For beams which are mounted on flexible supports, the impedance matching concept is found to be most applicable.

Design Procedure for Vibration Isolation on Non-Rigid Supporting Structures. Sheldon Rubin. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 100T.* 22 pp. Discussion of a procedure for the dynamic design of linear vibration isolators to protect a rigid equipment from the sinusoidal motions of a nonrigid supporting structure. A single degree of translational freedom of the equipment is assumed.

Material and Structural Damping for Vibration Control. B. J. Lazan. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 100U.* 21 pp. 16 refs. Discussion of the importance of near-resonant vibrations and of the role of system damping in their control. The various component parts of system damping are classified and analyzed.

Investigation of a Resonance-Free Vibration Isolation System. G. H. Klein. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 100Z.* 39 pp. 16 refs. Analysis of the behavior of a special two-degree of freedom system and presentation of its practical applications.

The Internal Damping Due to Structural Joints and Techniques for General Damping Measurement. D. J. Mead. *Gt. Brit., ARC CP 452* (Jan. 31, 1958) 1960. 41 pp. BIS, New York, $1.98. Discussion, in qualitative terms, of the source of damping in riveted or bolted joints which are subjected to harmonically varying loads. Several techniques for the measurement of structural damping are described, and a method is suggested for predicting the structural damping coefficient of a simple structure vibrating in a known mode and at known frequency.

Aeronautics, General

Special Issue: Executive and Personal Flying. *The Aeroplane & Astronautics*, May 20, 1960, pp. 611–626. *Partial Contents:* The Scene in Britain, John Fricker. Radio for the Amateur Flyer, Tim Vigors. British Radio for Light Aircraft. Aircraft Reviewed. Where You Can Fly. Principal Executive and Personal Aircraft of the World.

Luftfahrttechnik. *VDI Zeitschrift*, Apr. 21, 1960, pp. 473–502. 578 refs. In German. *Partial Contents:* Aerodynamik, F. W. Riegels. Neue Fluggerät-Formen—Von Flugplätzen unabhängig fliegende Geräte, Heinrich Hertel. Hubschrauber und andere Vertikalstartflugzeuge, Walter Just. Flugkörper, R. H. Reichel. Triebwerksanlagen, Otto Lutz. Raketenantriebe, R. H. Reichel. Flugkraftstoffe und Flugschmierstoffe, Günter Spengler and Elisabeth Kühn. Flugregelungen, Gerald Klein. Flugsicherung, Oskar Heer. Comprehensive survey of the aeronautical field covering such aspects as aerodynamics, new types of aircraft, helicopters and other VTOL and STOL aircraft, missiles, power plants, rocket propulsion units, fuels and lubricants, control systems, and air safety.

Die deutsche Luftfahrtindustrie. Hans-Georg Schulze. *Luftfahrttechnik*, Apr. 10, 1960, pp. 94–100. In German. Survey of the present status of German aircraft industry, emphasizing the size and range of activity of various enterprises. The survey is limited to companies dealing with the design and construction of aircraft, missiles, and power units, or those specializing in maintenance of similar aircraft equipment.

Il Periodo Pionieristico della Aeronautica Militare Italiana. Angelo Lodi. *Riv. Aero.*, Nov., 1959, pp. 2055–2078. In Italian. Historical survey of the development of Italian military aviation covering the period between 1884 and 1915.

La Tecnica Aeronautica Italiana dal 1909 ad Oggi. Amedeo Fiore. (*16th Natl. Aerotech. Congr., Pisa, Oct. 6, 1959.*) *L'Aerotecnica*, Oct., 1959, pp. 180–184. In Italian. Historical survey of the development of heavier-than-air craft covering the research done in Italy over the period from 1909 to 1959 in the field of aerodynamics, materials and structures, and propulsion.

Air Transportation

L'Aviazione Europea e il Mercato Comune Europeo. Giuseppe Simone. (*4th Italo-French "Leonardo da Vinci" Conf., Paris, Sept. 28, 29, 1959.*) *L'Aerotecnica*, Oct., 1959, pp. 158–168. In Italian. Outline of the development of air transport in Europe, comparison of air traffic operations in the U.S. and in Western Europe, and discussion of some economic aspects.

Airplanes

Air Conditioning, Pressurization

A Thermoelectric Air Conditioning Module for Sealed Cabins. H. L. Hall and P. L. Catron. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 159B.* 17 pp. Discussion of the design of the thermoelectric cooler for the feasibility model of a sealed environmental air-conditioning system. A brief general discussion of thermoelectric phenomena is included.

Control Systems, Automatic Pilots

Minimum Flyable Handling Qualities of Airplanes. Gifford Bull. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 171B.* 20 pp. Investigation to establish the minimum longitudinal handling qualities for returning an airplane to its base in an emergency, in case of failure of stability augmentation equipment.

Discussion of Some Design Problems Associated with Artificial Feel Systems of Airplanes with Irreversible Powered Flight Controls. Tsun-Ying Feng and D. C. Neil. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 171D.* 19 pp. 11 refs. Study of the longitudinal stick-free static and dynamic stability for aircraft with irreversible power controls. Methods of improving the aircraft flying and handling qualities are presented. In the stick-free dynamic analysis, residual oscillations of airplane normal acceleration following a step-stick force input and control forces in sudden pull-ups are studied for various feel systems.

O Dinamike System Upravleniia, Vkliuchaiushchikh Inertsial'nye Izmeriteli Koordinat. V. A. Bodner and M. S. Kozlov. *AN SSSR Otd. Tekh. Nauk Izv. Energ. i Avtom.*, Nov.-Dec., 1959, pp. 99–107. In Russian. Dynamic analysis of transient processes in closed control systems which include inertial coordinators.

Description

Special Issue: , Commercial Aircraft of the World. *The Aeroplane & Astronautics*, Apr. 29, 1960, pp. 515–534. *Partial Contents:* The Pattern of Success. Turbine Transport Order Book. Turbine Transports of the World.

The Canadair 44—A Breakthrough Cargo Aircraft. K. H. Larsson. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 170B.* 24 pp. Discussion of the design, performance, and economic aspects of a turboprop transport.

Das Vickers-Project VC 10. *Luftfahrttechnik*, Mar. 10, 1960, pp. 68–74. In German. Discussion showing that the rear engine layout of the Vickers VC 10 transport aircraft satisfies the requirement for better take-off and landing performance in the class of medium- and long-range jet airliners.

Turboreaktivnyi Samolet "152/II." Peter Stakhe. *Grazhdanskaia Aviatsiia*, Nov., 1959, pp. 23, 24. In Russian. Presentation of some data on the East German turbojet 152/II transaircraft.

P.16 Sales Sought Outside Switzerland. D. A. Anderton. *Av. Week & Space Tech.*, May 30, 1960, pp. 66, 67, 70–73, 75. Presentation of the design and performance characteristics of the Swiss fighter-bomber. Includes development history, fire power capabilities, and take-off and landing characteristics.

Fusoliere a Sezione non Circolare. Paolo Santini. *Cen. Consult. Stud. Ric. Aero. Mil., Monogr. Sci. Aero., Ser. V*, June, 1959. 31 pp. In Italian. Study of the distribution of stresses and displacements in a fuselage structure of noncircular section with rigid ribs. The complete solution of the problem is given and some typical results, explaining the effect of noncircularity, are presented.

A New Design Approach for Supersonic Transports. C. L. Blake. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 166A.* 11 pp. Discussion of the supersonic transport from the airline operators' point of view, and evaluation of a design approach to meet their requirements.

Der Vergrösserungsfaktor der Zusatzgewichte und das Gewichtsäquivalent der Zusatzwiderstände. Heinrich Hertel. *Luftfahrttechnik*, Apr. 10. 1960, pp. 100–104. In German. Discussion covering the increase factor of added weight and the weight equivalent of added drag. It is shown how the weights are interrelated with regard to the design requirements, and to what extent an elimination of added drag by aerodynamic improvements is advantageous.

Fuel Tanks

Convair 880 Fuel System Test Program. J. McCafferty and Glenn Karel. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 107V.* 16 pp. Discussion of the small-scale model tests, tests conducted on the full scale test stand, and the icing and low temperature test stand. The overall purpose of the test program is to demonstrate fuel system reliability before the first flight.

Landing, Landing Loads

Landing Aircraft Automatically and Reliably. E. W. Velander. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 171C.* 34 pp. Study of pilot prediction techniques and analysis of the results of data recordings from pilot landings in order to obtain a new approach to the flare computation problem. Prediction equations are developed for the control of the terminal conditions of the aircraft for the landing flare. Investigations of typical landings have revealed that the most satisfactory landings are at a sink rate of 2 ft. (or less) per sec.

Deck Landing. A. I. R. Shaw. *RAeS J.*, May, 1960, pp. 273–276. Description and discussion of the mirror landing sight, and of its advantage over the batsman-pilot system.

Landing Gear

A High Energy Absorption Landing Gear for VTOL Aircraft. Ch. L. Wharton, Jr. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 174C.* 22 pp. Brief discussion of the flight regime below the stall speed, flying as a conventional aircraft, as it applies to high performance VTOL jet powered aircraft; definition of an area of operation of the vehicle which appears to warrant investigation from an operational standpoint; and presentation of a new application of an old concept of landing gears in order to provide a method of alleviating the pos-

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sible operational difficulties associated with the low speed flight regime.

Telescoping Casters Lift Prime Mover, Permit Towing from Aircraft's Wheels. D. Eisbrenner. *Des. News*, Apr. 25, 1960, pp. 6, 7. Presentation of the design of a wheel-mover-unit which applies hydraulic power directly to the aircraft landing gear and which lifts itself off its drive wheels on hydraulic stilt-like casters, thus permitting the remote control of aircraft ground movement from either the aircraft cockpit or the ground.

Air-Cooled Brake. *Aircraft Eng.*, Apr., 1960, pp. 115, 116. Discussion of the problem that led to the development of a new brake system, the design of the brake-system, and its performance.

Operating Characteristics, Economics

The First Year of the Jet Age—Reflections. Appendix—On Resistance of a Tire Rolling in Standing Water. F. W. Kolk. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 110V.* 16 pp. Discussion of the experience gained in dealing with scheduling and operating problems. Mechanical reliability and the problem of noise are studied.

Supersonic Air Transports—An Airline Talks Back. B. S. Shenstone. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 166C.* 8 pp. Presentation of the objections, from an airline's point of view, to the Mach 3 transport aircraft.

The Boeing 707 in Service. R. M. Morgan. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 110T.* 13 pp. Presentation of the improvements incorporated in the design, and account of system problems and of flight incidents resulting from system or component malfunction.

Experience with the Caravelle. K. Hagrup. *Shell Av. News*, Apr., 1960, pp. 15–20. Discussion of the reasons behind SAS' selection of the Caravelle for their service, the crew training program, and the technical and operational experience with this aircraft.

Comet Take-Off Safety. *de Havilland Gazette*, Apr., 1960, pp. 64–66. Investigation of the problems of jet take-off technique and evaluation of the take-off characteristics of the new Comets.

Erfolgversprechende Startvorrichtung für Düsengrossflugzeuge unter Verwendung des Kuchschen Leitschienenprinzips. Georg Heuer. *Der Flieger*, Dec., 1959, pp. 414–416. In German. Survey of problems related to the use of large jet aircraft, covering take-off distances, airport locations, and noise. A launching device based on the Kuch principle is described.

Ein kritischer Vergleich der Startleistungen von Verkehrsflugzeugen mit Kolbentriebwerken und solchen mit Strahltriebwerken. Marius Lodeesen. *Flugwelt*, Jan., 1960, pp. 7–13. In German. Comparison of the take-off performances of commercial airliners with piston and jet engines.

The Potential of Nuclear-Powered Aircraft for Commercial Cargo Transport. J. F. Brady. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 169B.* 11 pp. Presentation of the advantages, performance characteristics, and economics of a nuclear-powered commercial aircraft. Data gained from a study of low-speed, low-radiation aircraft are used in the discussion.

Seating

Comfort Evaluation of the C-124 Crew Seat (Weber)—One of a Series of Studies Pertaining to the Design Evaluation of Pilot and Crew Station Equipment. R. F. Slechta, J. Forrest, W. K. Carter, and E. A. Wade. *USAF WADC TR 58-316*, Oct., 1959. 15 pp. Evaluation of certain design characteristics, using subjective and behavioral laboratory tests administered by means of hourly questionnaires presented to 17 subjects during a voluntary sitting period of seven hours' maximum duration. On the basis of test data and specific comments made by the subjects, recommendations for seat design improvements are made.

Airports

A Year of Jet Operation Experience at New York International Airport. T. M. Sullivan. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 109T.* 5 pp.

Atlantic Outpost Has New Terminal. *Airports & Airport Eng.*, Mar.-Apr., 1960, pp. 6–8. Presentation of the history and description of the newly improved facilities at Gander Airport in north-eastern Newfoundland.

Aviation & Space Medicine

Studies of Primate Tolerance to Some Complex Accelerations. N. P. Clarke and R. N. Headley. *USAF WADC TR 59-630*, Nov., 1959. 8 pp. Study exposing five primates to simulated deceleration in the forward facing position of up to 20 *g* combined with sine wave pitch oscillations through half amplitudes of 20° at 3 and 5 cps. Accelerometer readings and post-mortem examinations are discussed.

Design Study of High Pressure Oxygen Vessels. D. A. Keating. *USAF WADC TR 59-767*, Feb., 1960. 23 pp. Study of the feasibility of storing gaseous breathing oxygen under extreme high pressures for life support in flight operations.

Aircraft Oxygen Systems Used by the United States Air Force. D. R. Good. *USAF WADC TN 59-322*, Sept., 1959. 5 pp. 15 refs. Comparison of liquid and gaseous systems, considering weight, bulk, explosion hazards, ground servicing and stand-by losses, servicing hazards, complexity and reliability, freezing, temperature limitations, target area, orientation, and hydrocarbon contaminants.

Performance and Habitability Aspects of Extended Confinement in Sealed Cabins. T. D. Hanna. (*Aero Med. Assoc. 30th Annual Meeting, Los Angeles, Apr. 27, 1959.*) *Aerospace Med.*, May, 1960, pp. 399–406. Investigation to determine the effects on performance of six men during seven days of confinement in a small area at a simulated altitude of 10,000 ft. with an oxygen concentration equivalent to 55 per cent at sea level. The results show that no drastic deterioration in intellectual or psychomotor functions takes place over a seven-day period, although any deviation from optimum conditions tends to be magnified with increasing time in flight. It is suggested that simple routine tasks should be made less simple and routine and should be complemented with more complex tasks which require higher level behavior.

La Ingravidez. J. U. Abril. *Rev. Aero.*, Nov., 1959, pp. 918–924. In Spanish. Discussion of the phenomenon of weightlessness, including a survey of test facilities, results of some experiments on human and animal subjects, and consideration of medical aspects.

Walking Under Zero-Gravity Conditions. J. C. Simons. *USAF WADC TN 59-327*, Oct., 1959. 8 pp. Discussion of experiments with permanent magnetic sandals which enable a man to walk with an approximately normal gait under weightless conditions. A basic index is formulated to define magnetic requirements in terms of the inductive forces required to hold a subject stationary. A vector analysis of the 1-ϵ walking gait is also made.

Electron Microscopic Changes in Brain Tissue of Syrian Hamsters Following Acute Hypoxia. H. Hager, W. Hirschberger, and W. Scholz. (*Aero Med. Assoc. 30th Annual Meeting, Los Angeles, Apr., 1959.*) *Aerospace Med.*, May, 1960, pp. 379–387. 27 refs. EOARDC-supported research.

Influenza del Fumo Sulla Salute dell'Aviatore e Sulla Sua Resistenza Psico-Fisica al Volo. Tomaso Lomonaco. *Riv. Aero.*, Nov., 1959, pp. 1985–2003. In Italian. Discussion of the effect of smoking habits on pilot's health and his psychophysical resistance in flight.

Finger and Forearm Cutaneous Blood Flows During Changing Ambient Temperature. L. C. Senay, Jr., M. L. Christensen, and A. B. Hertzman. *USAF WADC TR 60-15*, Mar., 1960. 46 pp. 20 refs.

Evaluation of Personnel Exposure from Stratospheric Fission Fragment Contamination on Aircraft. J. L. Dick, M. C. Gaske, and L. A. Kiley, Jr. *Aerospace Med.*, May, 1960, pp. 353–371. 11 refs. Study to determine the extent of the build-up of radioactive debris on jet aircraft that routinely fly above the tropopause, to define the characteristics of the contamination, and to interpret the radiation levels observed in terms of possible exposure problem to personnel.

A Miniaturized Operant Conditioning Chamber for Behavioral Research in the Upper Atmosphere. F. H. Rohles, Jr., and Richard Coy. *USAF WADC TN 59-261*, July, 1959. 7 pp. Description of a miniaturized operant conditioning chamber for a mouse, designed for behavioral research in the upper atmosphere. It requires the animal to press a lever on a fixed ratio schedule of 25 : 1 for 20 min. out of every six hours for food reward.

Development of a Unit for Recovery of Water and Disposal or Storage of Solids from Human Wastes. I—The Study Phase. J. D. Zeff and R. A. Bambenek. *USAF WADC TR 58-562, Pt. I*, Nov., 1959. 47 pp. 19 refs.

Development of an Oxygen Partial Pressure Transducer. E. B. Weis, Jr., Adolf Marko, M. A. McLennan, and E. G. Correll. *USAF WADC TN 59-395*, Nov., 1959. 15 pp. Investigation made to develop a method for monitoring oxygen supply of man during stress experiments, leading to the selection of the polarographic principle. The polarographic system of analysis is examined in detail, and a modified polarographic cell with a bare cathode and fast response time is studied.

Range Limitations of the CRL Model 8 Master-Slave Manipulator with the Seated Operator. D. F. Baker and B. M. Crawford. *USAF WADC TN 59-359*, Oct., 1959. 12 pp. Study to determine the extent of limitations upon the inherent work range of the master-slave manipulator when the operator is seated. Contours of effective performance areas in five horizontal planes are determined.

Model 16 Automatic Blood Pressure Measuring Instrument. R. A. Johnson. *USAF WADC TR 59-429*, Dec., 1959. 45 pp.

Oxygen Sources for Space Flights. R. M. Bovard. *Aerospace Med.*, May, 1960, pp. 407–412. Discussion of the use of potassium superoxide and sodium chlorate as means of controlling a closed chamber atmosphere. Current applications are presented, and data on the chemical behavior of potassium superoxide in these applications are compared with lithium hydroxide and other carbon dioxide adsorbers. The possibility of using sodium chlorate candles as an emergency source of a surge of oxygen in conjunction with a potassium superoxide system is demonstrated.

Pronitsaemost' Gematoentsefalicheskogo Bar'era kak Pokazatel' Sostoianiia Akklimatizatsii k Gipoksii. N. A. Verzhbinskaia. *AN SSSR Dokl.*, Feb. 21, 1960, pp. 1374–1377. In Russian. Description of tests made on animal subjects to determine the process of acclimatization to hypoxia.

Engineering of the Sealed Cabin Atmosphere Control System. S. L. Jacobson. (*Aero Med. Assoc. 30th Annual Meeting, Los Angeles, Apr. 29, 1959.*) *Aerospace Med.*, May, 1960, pp. 388–398. Discussion of the control of carbon dioxide and temperature, as well as the supply of oxygen. Weight-time curves are included.

Target Size and Visual Recognition. W. C. Steedman and Ch. A. Baker. *USAF WADD TR 60-93*, Feb., 1960. 18 pp.

Human Engineering

Man and Space. Lester Carlyle. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 173A.* 11 pp. Description of procedures to determine functional human envelopes for flight in vehicles operating within and beyond the earth's atmosphere.

Human Engineering Payoff. J. A. MacDonald. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 173B.* 7 pp. Discussion of Air Force developments in crew equipment and flight instrumentation and of future trends in the field of human engineering.

Prediction of Advanced Levels of Proficiency in a Complex Tracking Task. J. F. Parker, Jr. *USAF WADC TR 59-255*, Dec., 1959. 57 pp. 23 refs.

A Method for Performing Human Engineering Analysis of Weapon Systems. Albert Shapero and Charles Bates, Jr. *USAF WADC TR 59-784*, Sept., 1959. 68 pp. Presentation of a weapon system analysis and integration model including the system's human elements, which can be employed as an aid in the analysis, evaluation, planning, and management control of weapon systems.

Task Performance with the CRL Model 8 Master-Slave Manipulator as a Function of Color-Coding, Distance, and Practice. D. F. Baker and B. M. Crawford. *USAF WADC TR 59-728*, Nov., 1959. 16 pp. Investigation to determine the ability of master-slave manipulator operators to identify the slave hands and their movements with corresponding components and functions of the human body, specifically forearm, wrist, and finger movement.

Chemistry

The Spectra of Nitrogen Oxides. II—The Urey-Bradley Force Constants in N_2O_4 and the Infrared Spectrum of Solid $N_2{}^{15}O_4$. Appendix I—Correction of the Force Constants by the Least Square Process. Appendix II—Programming of the IBM 650 Digital Computer. I. C. Hisatsune. *Kansas State U. Sci. Rep. 2 (AFCRC TN 60-277)*, Feb., 1960. 47 pp. 29 refs.

The Spectra of Nitrogen Oxides. III—The Spectrum of N_2O_3. I. C. Hisatsune. *Kansas State U. Sci. Rep. 3 (AFCRC TN 60-263)*, Feb., 1960. 38 pp. 30 refs.

Flash Photolysis. L. I. Grossweiner. *Sci. Am.*, May, 1960, pp. 135–138, 141–145. Presentation of a new method of identifying intermediary products in fast photochemical processes. The mechanism of such a reaction is discussed and the results obtained with the new analytical method are presented.

The Theory of Volume Recombination of Ions. G. L. Natanson. (*Zhurnal Tekh. Fiz.*, Nov., 1959, pp. 1373–1380). *Sov. Phys. - Tech. Phys.*, May, 1960, pp. 1263–1269. 15 refs. Translation. Presentation of an expression for the recombination coefficient α which holds for all pressures and transforms into expressions which agree with the corresponding theories of Thomson and Langevin, thus combining their advantages.

The Distribution of Ions Formed by Attachment of Electrons Moving in a Steady State of Motion Through a Gas. C. A. Hurst and L. G. H. Huxley. *Australian J. Phys.*, Mar., 1960, pp. 21–26. Derivation of an exact solution for the distribution of ions and comparison of results with an approximate calculation given earlier by Huxley.

A New Instrument for the Determination of Molecular Weight by Differential Vapor Pressure. N. M. Wiederhorn, I. H. Vreeland, and R. H. Thomson. *USAF WADC TR 59-724* Feb., 1960. 11 pp.

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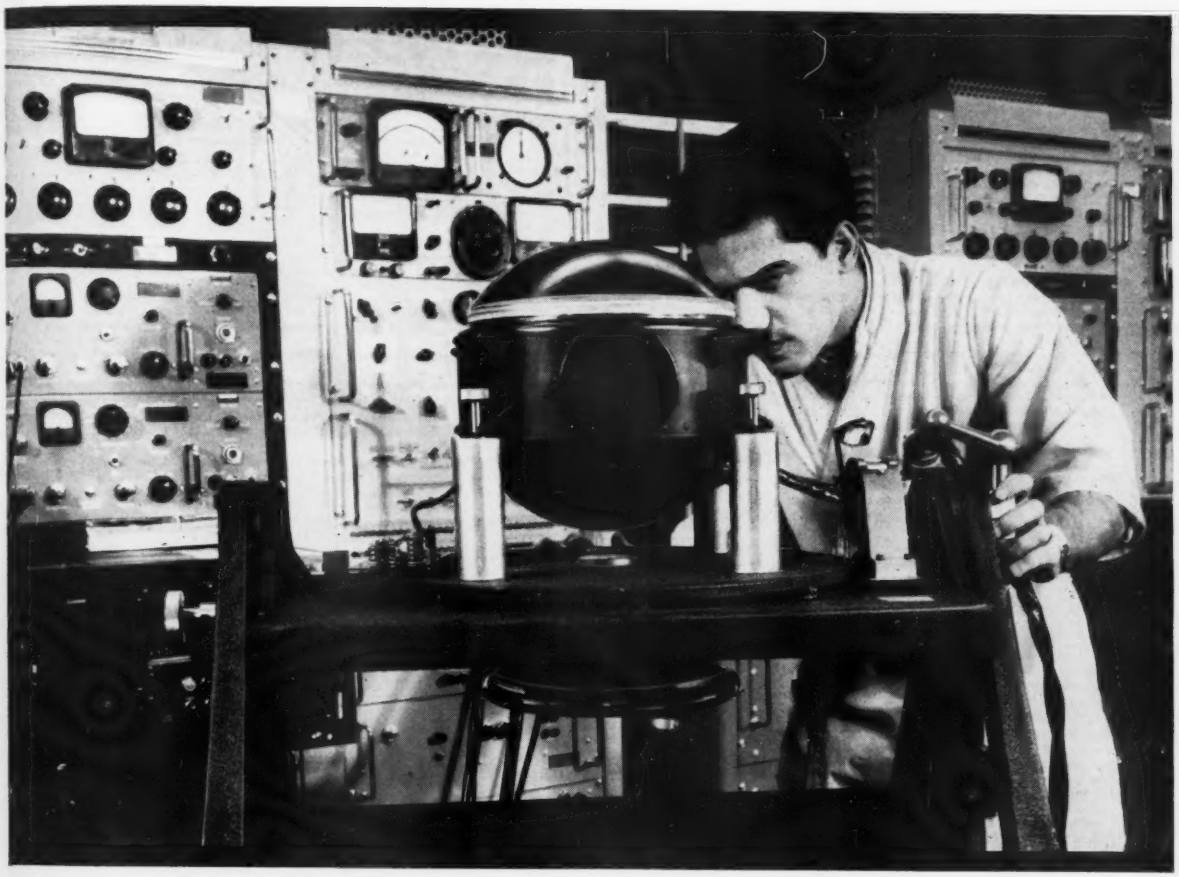

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Urea Inclusion Compounds of Acetylene Derivatives. Jack Radell, J. W. Connolly, and L. D. Yuhas. *USAF WADC TR 59-672*, Feb., 1960. 9 pp. 11 refs.

Vliianie Soderzhaniia Khroma na Elektrokhimicheskoe i Korrozionnoe Povedenie Splavov Zhelezo-Khrom. G. M. Florianovich and Ia. M. Kolotyrkin. *AN SSSR Dokl.*, Jan. 21, 1960, pp. 585–588. 11 refs. In Russian. Study of the effect of chromium content on the electrochemical behavior and resistance to corrosion of iron-chromium alloys.

Computers

Survey of Analog Cross-Spectral Analyzers. L. J. Seltzer and D. T. McRuer. *USAF WADC TR 59-241*, Dec., 1959. 72 pp. 28 refs. Discussion of the principles underlying the analog devices which have been used to compute cross-spectra in the processing of data from human response experiments. Where available, the results of calibration experiments are included as a measure of specific performance.

Network Analogs for Mechanical Systems. J. J. Hupert. *Elec. Mfg.*, June, 1960, pp. 106–124. 34 refs. Discussion of the analogies between electrical network equations, in two alternative formulations, and those of mechanical and electromechanical systems. Only linear systems are discussed, and the fact is emphasized that there are two essential types of electric-circuit analogs based on (a) loop, or mesh, and (b) nodal systems of equations.

Direct Metering for a Transformer Analogue Computer. J. F. Young. *Electronic Eng.*, May, 1960, pp. 280–288. 12 refs. Discussion of the individual circuit arrangements for a metering system, as well as of the metering system as a whole.

The Application of the Analog Computer to Solutions of Some Non-Linear Integral and Integro-Differential Equations. Ryszard Gawroński. *Vibration Prob. Proc.*, No. 2, 1959, pp. 37–42.

Determining Transfer-Functions with Analog Computers. J. H. Milsum. *ISA J.*, Apr., 1960, pp. 54–57. Presentation of a "mask" matching technique by which a maximum of four unknown constants of a transfer function can readily be determined within a few minutes to one per cent accuracy.

Frequency-to-Period-to-Analog Computer for Flowrate Measurement. T. W. Berwin. *IRE Trans., EC Ser.*, Mar., 1960, pp. 62–71. Discussion of a special purpose nonlinear analog computer which accepts an a.c. voltage of varying frequency, acts upon the period of each cycle, computes the inverse of the time period, $e = 1/T$, and holds the information for the period of the next cycle. Application of the computer is described and results presented for fast readout and recording of gas and liquid turbine type flowmeters.

An Investigation of Sampling Measurement of Time Varying Random Signals Through Information Theory. Yasushi Ishii. *U. Tokyo Aero. Res. Inst. Rep. 350*, Feb., 1960. 16 pp. Derivation of a formula which gives the average information amount per unit time obtained through the sampling measurement of a Gaussian random signal.

An Evaluation of AM Data System Performance by Computer Simulation. R. A. Gibby. *Bell System Tech. J.*, May, 1960, pp. 675–704.

O Vozmozhnosti Korrektsii Metodicheskoi Oshibki Tsifrovogo Differentsial'nogo Analizatora. S. V. Misailovskii. *AN SSSR Otd. Tekh. Nauk Izv. Energ. i Avtom.*, Nov.-Dec., 1959, pp. 156–161. In Russian. Study covering the possibility of correcting the methodical error in digital differential analyzers occurring in simple individual functional integrator schemes.

Control Theory

The Theory of Quality of Nonlinear Control Systems. Chzhan Sy-In. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 971–974.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1387–1392. Translation.

Application of the Residue Theory to Transformation of Automatic Control Systems Equations to Canonic Variables. O. I. Komarnitskaia. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 845–850.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1209–1217. Translation. Presentation of a method of constructing the transformation matrix, which permits the transformation coefficients to be determined for any structure of the roots of the characteristic equation.

Digital Speed-Control Analysis by Analog-Computer Methods. D. W. Leiby. *Elec. Mfg.*, May, 1960, pp. 178–186. Description of a numerical speed-control system combining analog and digital computer methods. Transient performance is investigated for changes in reference speed and operating load. The results show the effects of sampled-data and quantized-data operation upon the performance of such systems.

Dynamics of Hot-Gas Servos. R. V. Halstenberg and W. A. Kaufmann. *Elec. Mfg.*, May, 1960, pp. 165–170. Discussion of the components of hot-gas servosystems and analysis of their performance. It is found that a particular problem is the control of the dynamic response of an actuator which is driven by an extremely compressible fluid.

A High Speed Electrohydraulic Servomechanism. Yô Ikebe and Kôzô Matsushima. *Tokyo Inst. Tech. Bul., Ser. B*, No. 5, 1959, pp. 1–10. Discussion of convenient methods for the dynamic characteristic test of a positional servomechanism. The results show that the behavior of the electrohydraulic servomechanism is greatly improved by the insertion of a simple compensating network.

A Simplified Description of Electrohydraulic Servo Valve Operation. Bill Molander. *Kearfott Tech. News Bul.*, Nov.-Dec., 1959, pp. 12–14. Presentation of the design and operation sequence of one of Kearfott's three major servovalve designs.

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Les Simulateurs. I—Simulateurs de Vol. M. Lermoyez. *Docaéro*, Nov., 1959, pp. 3–16. In French. Discussion of the requirements and operating principles of flight simulators. The use of combinations of analog computers is illustrated and a simplified analog simulator is analyzed. A discussion of helicopter simulators is also included.

Using Ground-Control Radar to Improve Flight Simulation. P. W. Staiger. *Electronics*, May 13, 1960, pp. 86, 87. Description of a system which ties an F-86 flight simulator into standard operational GCI equipment, the simulator being over two miles away from the GCI site.

Electronics

Photoemitter Preparation by Empirical and Microbalance Techniques. Eugene Heath. *USAF WADC TR 60-5*, Feb., 1960. 43 pp.

Semi-Automatic Air Defence Control System for Sweden. *Saab Sonics*, No. 28, 1960, pp. 10, 11. Discussion of Sweden's surveillance and operations control system that includes special guidance transmitters to supply pilots with guidance data, and which can be developed so as to actuate the aircraft autopilot directly.

Generating High-Quality Characters and Symbols. J. K. Moore and Marvin Kronenberg. *Electronics*, June 10, 1960, pp. 55–59. Discussion of the design and operation of a new solid-state character generator, developed for visual information display and control systems, which combines high speed with character quality, stability, simplicity of adjustment, high display intensity, and reliability.

Amplifiers

Comparison of Gain, Bandwidth and Noise Figure of Variable-Reactance Amplifiers and Convertors. J. D. Pearson and J. E. Hallett. (*IEE Paper 3224 E.*) *IEE Proc., Pt. B*, May, 1960, pp. 305–310. Presentation of formulas for the gain-bandwidth products and noise figures of a variable-reactance amplifier and converter. It is shown that for equal gains and noise figure, the converter has a greater bandwidth than the amplifier.

Packaged Tunable L-Band Maser System. F. R. Arams and S. Okwit. *IRE Proc.*, May, 1960, pp. 866–874. 17 refs. Description of a low-noise, tunable *L*-band maser system. The maser and circulator have been packaged into an operational unit which includes all auxiliary components and has a system noise factor of 0.5 db. (35°K.). Electrical and mechanical features of the system are described and performance data are given.

Influența Armonicilor pare Asupra Principalilor Parametri ai Amplificatoarelor Magnetice cu Înfășurările de Lucru Legate în Serie. I. Bejan, Gh. Șerban, and V. Corlățeanu. *Iași Politeh. Inst. Bul.*, Fasc. 3–4, 1958, pp. 253–258. In Rumanian, with summaries in Russian and French. Determination of the effect of even harmonics on the main parameters of magnetic amplifiers.

Antennas, Radomes

Predicting the Antenna's Role in RFI. Ernest Jacobs. *Electronic Ind.*, May, 1960, pp. 96–102. 10 refs. Presentation of equations for the prediction of interference from antennas and for facilitating the calculations of antenna gain, power transfer between two antennas in free space, power density, and other parameters.

Krátkovlnné Letadlové Antény. Antonín Wild. *Zpravodaj VZLÚ*, No. 2, 1959, pp. 47–50. In Czech. Discussion of the types and the characteristics of various aircraft HF antennas.

Just How Transparent is Your Radome? D. A. Bell. *Space/Aeronautics*, May, 1960, pp. 170–172. Study of the principal undesired effects of a radome on airborne weather radars: losses in maximum range and angular resolution. Both losses are analyzed, and simple mathematical expressions are derived to show their effect on radar performance.

Modified Luneberg Lens for Defocused Source. D. K. Cheng. *IRE Trans., AP Ser.*, Jan., 1960, pp. 110, 111. Presentation of curves for the required index of refraction for a modified Luneberg lens which possesses the same collimating property for a point source located at a small distance outside the lens.

Radiation Pattern Synthesis with Sources Located on a Conical Surface. A. Ishimaru and G. Held. *IRE Trans., AP Ser.*, Jan., 1960, pp. 91–96. 12 refs. USAF-supported presentation of various methods to obtain the source function for those sources which are placed in a region where the circumferences measure approximately less than two wavelengths, where the circumference is less than approximately $4/3\ \pi$ wavelengths, and when the sources are located far from the cone tip.

Transmission-Line Missile Antennas. Ronold King, C. W. Harrison, Jr., and D. H. Denton, Jr. *IRE Trans., AP Ser.*, Jan., 1960, pp. 88–90. Analysis of a class of protruding rocket antennas of low silhouette in terms of an approximately equivalent circuit which consists of a shunt-driven transmission line terminated in a reactor at each end. The Poynting vector is determined, the radiation resistance is referred to the current in the generator, and the reactance is obtained.

Antenna Image Quality Evaluation. I—By an Optical Simulation Method. II—By a Mechanical Observer. J. J. Myers. *IRE Trans., AP Ser.*, Jan., 1960, pp. 78–87. 13 refs. USAF-Navy-supported presentation of the techniques used to study the effect of aperture illumination on image quality for a high resolution antenna. The results of the evaluation of a typical class of illuminations are given.

The Calculation of Reflector Antenna Polarized Radiation. L. E. Raburn. *IRE Trans., AP Ser.*, Jan., 1960, pp. 43–49. Presentation of a partly analytical process for calculating the far-zone patterns of reflector antennas which may have nonlinear polarization. Calculated and measured patterns are given for a fan-beam antenna whose reflector is 120 λ high and 30 λ wide.

Tables of Taylor Distributions for Circular Aperture Antennas. R. C. Hansen. *IRE Trans., AP Ser.*, Jan., 1960, pp. 23–26.

Design of Circular Apertures for Narrow Beamwidth and Low Sidelobes. T. T. Taylor. *IRE Trans., AP Ser.*, Jan., 1960, pp. 17–22. USAF-supported presentation of a family of continuous circular aperture distributions making possible an asymptotic approach to the condition of uniform sidelobes.

On Uniform and Linearly Tapered Long Yag Antennas. D. L. Sengupta. *IRE Trans., AP Ser.*, Jan., 1960, pp. 11–17. 14 refs. Review of the traveling-wave analysis of long Yagi antennas, and discussion of a method of designing a Yagi antenna. An approximate theory is developed for the linearly tapered long Yagi antenna which is verified by actual measurements.

The Flight Evaluation of Aircraft Antennas. G. W. Leopard. *IRE Trans., AP Ser.*, Mar., 1960, pp. 158–166. Review of the parameters involved in a flight evaluation under both standard and nonstandard propagation conditions. The procedures used and the results obtained are also discussed.

The Slot Antenna with Coupled Dipoles. R W. P. King and G. H. Owyang. *IRE Trans. AP Ser.*, Mar., 1960, pp. 136–143. Formulation and analysis of the problem of an array consisting of a slot antenna and two symmetrically located cylindrical dipoles. An experimental setup for measuring the radiation patterns is described and measured, and theoretical patterns are displayed.

Ground-Mapping Antennas with Frequency Scanning. A. Bystrom, R. V. Hill, and R. E. Metter. *Electronics*, May 6, 1960, pp. 70–73. Discussion of frequency-scanned ground-mapping antennas, presenting a method of controlling the transmitted beam accurately by controlling the driving frequency of an array. A slotted aperture array and a leaky grid array proving the feasibility of this method are discussed.

Theory of Coupled Folded Antennas. C. W. Harrison, Jr., and Ronold King. *IRE Trans., AP Ser.*, Mar., 1960, pp. 131–135. Derivation of formulas for the mutual and self-impedance of two identical nonstaggered parallel-folded dipoles. A generalization of the theory permits the determination of these impedances for any identical dual configuration of wires, no matter how complicated, provided the structures are symmetrical with respect to the driving points. The uses of the theory are: (1) determination of the performance of a two-element folded antenna array, when one antenna is a tuned parasite, functioning as a director or a reflector, and (2) determination of the driving-point impedance of a folded antenna parallel to a highly-conducting plane.

Optimum Antenna Height for Ionospheric Scatter Communication. R. G. Merrill. *IRE Trans., CS Ser.*, Mar., 1960, pp. 14–19. 10 refs. USAF-supported discussion of the height gain function resulting from raising and lowering symmetric transmitting and receiving antennas for a fixed path length. Radiation patterns of elevated antennas over spherical earth for scatter propagation in the lower ionosphere incorporating refraction, parallax, spherical divergence, tropospheric defocusing, and near-horizon diffraction were used to compute the function whose maximum is defined as the optimum antenna height.

Conflicting Demands in Radome Design. F. R. Youngren. *Aircraft & Missiles*, June, 1960, pp. 46, 47. Discussion pointing out the conflict between the ideal shape for electromagnetic requirements and the ideal shape for aerodynamic requirements. Problems posed by rain erosion, salt encrustation, and moisture penetration are also noted.

Circuits & Components

Semiconductor Networks for Microelectronics. J. W. Lathrop, R. E. Lee, and Ch. H. Phipps. *Electronics*, May 13, 1960, pp. 69–78. Discussion of how a circuit is developed from a diagram to a network on and within a single-crystal semiconductor wafer. It is pointed out that selective diffusion and shaping of a semiconductor to form complete circuits reduces size and weight and improves reliability.

Communications

Advanced ATC Communications. J. P. O'Brien. *J. Air Traffic Control*, Apr., 1960, pp. 1–4. Presentation of the performance requirements and the history of the Automatic Ground Air Communications System which is a time division, two-way data link for the mutual exchange of information between the ground and air environments. Experimental system parameters are included.

Untersuchungen über Verzerrungen beim Überdeckungs-System des UKW-Sprechfunknetzes. H. Mattes. *DVL Bericht No. 87*, Oct., 1959. 53 pp. 10 refs. Westdeutscher Verlag, Köln & Opladen. In German. Survey of the development of VHF radio communications, with particular emphasis on coverage systems, and discussion of the fundamental and systematic deficiencies of the system. Methods for eliminating these deficiencies are evaluated; interferences due to the multiple reception of different transmitters in the same frequency channel are considered along with those generated by amplifiers, transmission cables, and other audio frequency devices.

Missile Communication During Reentry Blackout. K. M. Baldwin, O. E. Bassett, E. I. Hawthorne, and E. Langberg. *Electronics*, May 27, 1960, pp. 105–109. Discussion of the design and operation of a system which, by using a sufficiently high communication frequency, eliminates the communication blackout that occurs during missile re-entry because of plasma sheath formation. The recovery package, the ejectable data cassette, the missile-borne K_a-band antenna system, the receiving system, a typical PPM modulator, and the data capacity are discussed. A study of the concept of plasma and its characteristics is included as an introduction into the subject.

Transmitter Power Control in Two-Way Communications System. G. S. Axelby and E. F. Osborne. *IRE Trans., CS Ser.*, Mar., 1960, pp. 48–56. Presentation of the theory of controlled-power operation. Verification of basic control loop principles was obtained on the electronic analog computer. Feedback control is applied to high reliability systems to vary the transmitted power as a function of the fading and, consequently, to reduce operating cost by conserving transmitted power, and to reduce interference to other radio networks in the area.

Data Transmission Tests on Tropospheric Beyond-the-Horizon Radio System. F. E. Willson and W. A. Runge. (*4th Natl. Aero-Commun. Symposium, Utica, Oct. 21, 1958.*) *IRE Trans., CS Ser.*, Mar., 1960, pp. 40–43. Presentation of results of data transmission tests made on both single-link and multi-link tropospheric behind-the-horizon radio systems. Data were satisfactorily transmitted on a 2,400 mile circuit consisting of nine different beyond-the-horizon paths and six line-of-sight paths. The FM-type data modulation was notably superior to the AM type.

Il Linguaggio nella Teoria e nella Tecnica delle Telecomunicazioni e Sue Applicazioni Aeronautiche Internazionali. Giuseppe Pasquarelli. *Riv. Aero.*, Oct., 1959, pp. 1881–1902. In Italian. Discussion covering the requirements of modern telecommunications and application to the international field of aeronautics, analyzed in terms of progress achieved in space exploration.

Construction Techniques

Increased Reliability of Aviation and Missile Electronics by Use of Damped Structures. Appendix—Transfer Response Function of a Clamp-Free Beam. J. E. Ruzicka. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 100Y.* 28 pp. 16 refs. Discussion of the control of elastic body resonances by use of damped structures. Several idealized models of the problem are analyzed, constructed, and tested to demonstrate the effect of highly damped structures.

Materials and Techniques for Microminiaturization. II. P. J. Franklin and E. F. Horsey. *Elec. Mfg.*, June, 1960, pp. 135–140. 33 refs. Discussion of the new materials and techniques used in the microminiaturization of capacitors, diodes and transistors, protective coverings, inductors, and integrated solid circuitry. It is shown that the trend is away from plastics and toward inorganic materials.

Cooling

Hidden Design Factors for Thermoelectric Coolers. J. C. Carroll. *Space/Aeronautics*, May, 1960, pp. 166–169. Analysis of design factors affecting thermoelectric cooling systems. Joulean heat loss, variation of the net refrigeration rate of a Peltier couple with current, and coefficients of performance are treated. Performance curves and typical cooler modules are shown.

Thermoelectric Refrigeration. W. L. Wright. *Elec. Eng.*, May, 1960, pp. 380–384. Discussion of several devices which represent applications of practical thermoelectric cooling in the electronics industry and in medicine.

Heat Sinks for Power Transistors. A. F. Lohman. *Electronic Ind.*, May, 1960, pp. 83–86. Presentation of a simple method for the rapid determination of the best heat transmission path for semiconductor power devices.

Dielectrics

Reaktivnyi Metod Izmereniia Dielektricheskikh Poter'. K. S. Poluliakh. *Izmer. Tekh.*, Oct., 1959, pp. 42–45. In Russian. Description of a method for measuring dielectric losses in instruments not requiring a high degree of accuracy.

Magnetic Devices

Special Issue: Proceedings of the Fifth Symposium on Magnetism and Magnetic Materials. (*Conf. on Magnetism & Magnetic Materials, Detroit, Nov. 16–19, 1959.*) *J. Appl. Phys., Suppl.*, vol. 31, May, 1960. 425 pp. 1,282 refs. Compilation of 170 articles on the following subjects: general theory of magnetism, garnets, permanent magnets, spin waves and magnetostatic modes, computers and switching, anisotropy, techniques and devices, resonance, soft magnetic materials, ferrites and oxides, magnetic films, metals and alloys, magnetic salts, magnetic compounds and neutron diffractions, and ferrimagnetic resonance effects.

Studies in Partial Switching of Ferrite Cores. R. H. Tancrell and R. E. McMahon. *J. Appl. Phys.*, May, 1960, pp. 762–771. USAF-Army-Navy-supported investigation of Mg-Mn ferrite cores in partially switched states. Consideration is given to the percentage of flux switched at various locations within a core, as well as the speed of this switching.

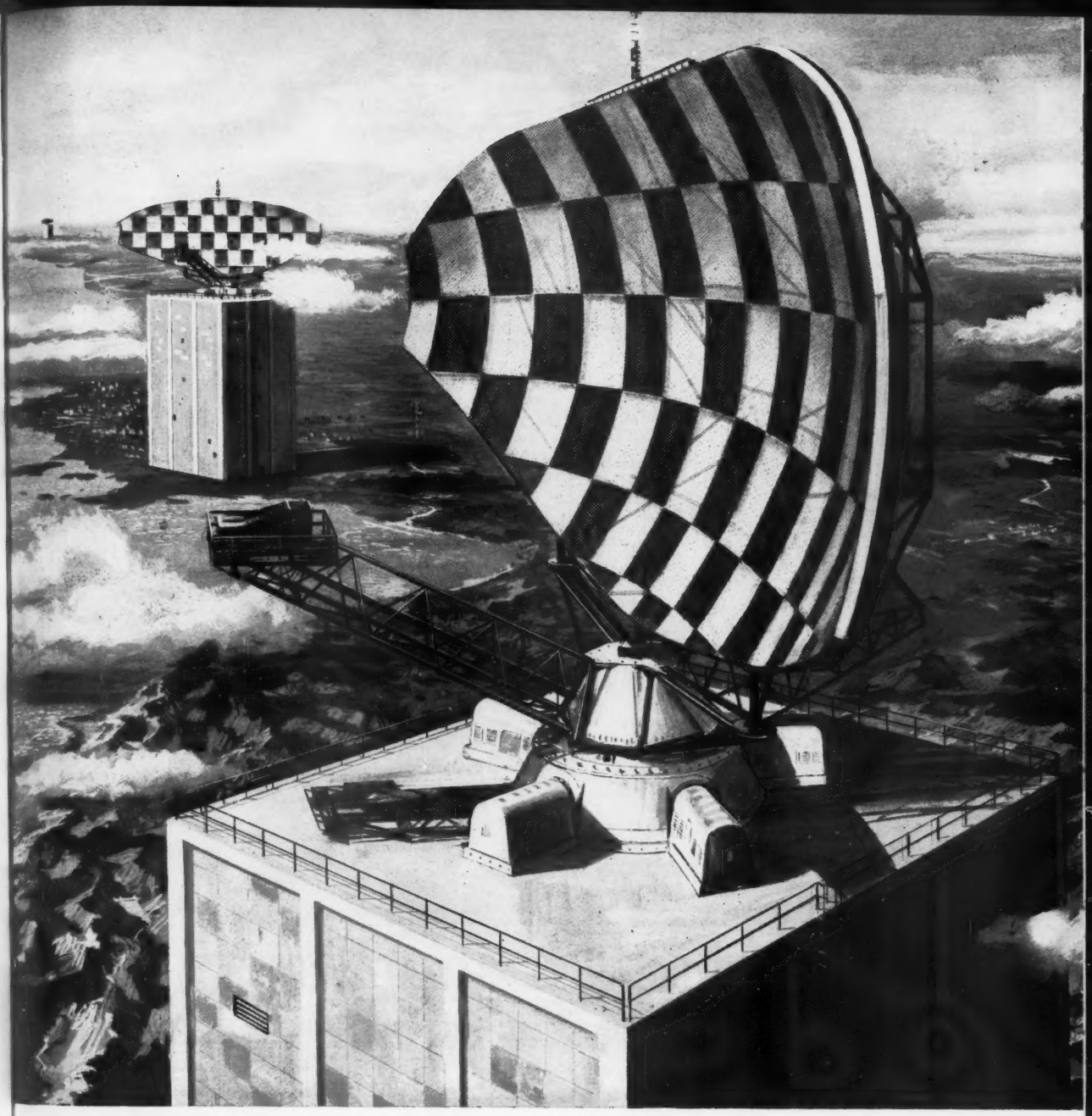
Priblizhennyi Metod Rascheta Osnovnogo Sostoianiia Izotropnogo Antiferromagnetika. Pu Fu-Cho. *AN SSSR Dokl.*, Feb. 21, 1960, pp. 1244–1247. In Russian. Application of an approximate method, based on spectral representation of Green's functions, to the theory of antiferromagnetism without taking into account anisotropy. The derived magnetization formula is valid for all temperatures.

Dynamical Equations of Motion and Solving Functions for Elastic and Inelastic Anisotropic Bodies in the Magnetic Field. S. Kaliski and J. Petykiewicz. *Vibration Prob. Proc.*, No. 2, 1959, pp. 17–35.

The Remanence of Alnico V and VI Magnets Between Room Temperature and 550°C. R. K. Tenzer. *USAF WADC TR 59-438*, Jan., 1960. 15 pp.

High Power Effects on Ferrimagnetic Resonance. M. T. Weiss. *J. Appl. Phys.*, May, 1960, pp. 778–782. Investigation of single-crystal spheres of manganese ferrite at high microwave power levels. The variation of susceptibility with power level is in good agreement with Suhl's theoretical treatment of the saturation process in which scattering of the uniform precession into spin waves caused by impurities and imperfections is taken into account.

Issledovaniia Effekta Kholla i Poperechnogo Magnitnogo Soprotivleniia v Germanii v Pole do 400 Kiloerstedt. V. R. Karasik. *AN SSSR Dokl.*, Jan. 21, 1960, pp. 521, 522. In Russian. Investigation of the Hall effect and the transverse magnetic resistance in germanium in a field up to 400 koersteds.



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SPERRY

Measurement & Testing

Measurement of Materials for Thermoelectric Generators. C. S. Duncan and G. W. Wilson. *Elec. Eng.*, May, 1960, pp. 372–378. Discussion of the measurement methods, of the factors which can be revealed by the various methods, and of the choice of methods applicable for a specific purpose.

Measurement of the Parameters in the Thermoelectric Figure of Merit. E. H. Lougher. *Elec. Eng.*, May, 1960, pp. 358–364. 22 refs. Presentation of some of the more effective methods for measuring such parameters of thermoelectric materials as the Seebeck coefficient, thermal conductivity, and electric resistivity.

Radar Tester Needs Wide Band AFC. J. T. Harper and J. L. Redifer. *Electronic Ind.*, May, 1960, pp. 92–95. Discussion of the wide-band automatic frequency control used in a radar target simulator designed for use in automatic tactical ground support equipment for the MD-7 fire control system.

Noise, Interference

Wide Band Noise Generator. E. J. Grobe and R. W. Wolfe. *USAF WADC TR 59-664*, Jan., 1960. 59 pp. 14 refs.

On the Stability of Random Systems and the Stabilization of Deterministic Systems with Random Noise. J. C. Samuels. *ASA J.*, May, 1960, pp. 594–601. 10 refs. Presentation of a general theory of mean square stability of random linear systems when several system parameters vary as white noise stochastic processes. The theory is applied to the mean square stability of an RLC circuit in which the resistance and capacitance have purely random fluctuations. A new type of dynamic stability is predicted—i.e., the possibility of stabilizing unstable deterministic systems with random noise.

Apparent Thermal Noise Temperatures in the Microwave Region. Eric Weger. *IRE Trans., AP Ser.*, Mar., 1960, pp. 213–217. USAF-sponsored research.

Frequency Scintillations of Satellite Signals Before and After the Argus Experiments. P. R. Arendt. *IRE Trans., AP Ser.*, Jan., 1960, pp. 73–77. Discussion of the alteration of the established scintillation index during a time interval in August and September, 1958—i.e., before, during, and after the well known Argus experiments. The observations indicate that no long-living ionospheric inhomogeneities were produced within the zones of the ionosphere which could be checked from ground stations.

Piezoelectricity

Ferroelectric Materials and Their Applications. Alfred Kremheller. *Sylvania Tech.*, Apr., 1960, pp. 42–48. 44 refs. Introduction to the field of ferroelectrics, including a discussion of the hysteresis loop, the Curie-Weiss law, classification of ferroelectrics, and the theories of ferroelectricity, as well as the applications of ferroelectrics.

Method for Measuring the Dielectric Constant of Ferroelectric Ceramics at S-Band Frequencies. C. B. Sharpe and C. G. Brockus. *Am. Ceram. Soc. J.*, June, 1960, pp. 302–305. 11 refs. Army-sponsored research.

Power Supplies

Perspective on Direct Power Conversion. S. P. Kaprielyan. *Aircraft & Missiles*, May, 1960, pp. 22–24. Discussion of the basic principles involved in thermoelectric generators, magnetohydrodynamic generators, and in high-temperature fuel-cells. Materials and the basic design of these devices are studied.

Magamp Regulator for DC-to-DC Converters. Baruch Berman. *Electronic Des.*, June 8, 1960, pp. 70–73. Discussion of the use of a magnetic amplifier as a regulator for solid-state d.c. to d.c. converters. A design is presented for an efficient, light-weight unit that will provide ±2 per cent regulation over a wide range of input voltages and loads.

Linear Circuits Regulate Solid-State Inverter. Roger Wileman. *Electronics*, Apr. 15, 1960, pp. 61–63. Discussion of a transistorized d.c. to a.c. inverter which uses linear circuits to obtain precise voltage regulation of output. The design and operation of a 50-watt unit capable of delivering a 115 volt r.m.s. 400 cps output regulated ±0.2 per cent is studied.

Recent Progress in Thermoelectricity. S. J. Angello. (*AIEE Winter Gen. Meeting, New York, Jan. 31–Feb. 5, 1960.*) *Elec. Eng.*, May, 1960, pp. 353–357. 21 refs. Discussion of the theory of thermoelectricity, of thermoelectric effects of interest in both power generation and refrigeration, and of the present state of materials development.

Transistorized Four-Segment Commutator for a Direct-Current Machine. F. L. Schwartz. *USAF WADC TR 59-682*, Feb., 1960. 40 pp. 18 refs.

The Thermionic Power Converter and Its Applications. J. G. Leisenring. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 159C.* 28 pp. 23 refs. Discussion of the thermionic converter and of its operating principles and applications as an electrical power generator or high-temperature sensor in space, airborne, ground, or subsurface systems. Application requirements and limitations are discussed for these various systems.

Engineering Standards for the Comparison of Direct Electrical Conversion Devices. F. W. Anders. *SAE Natl. Aero Meeting, New York, Apr. 5–8, 1960, Preprint 159A.* 10 pp. Presentation of a simple method for assessing the status of modern laboratory techniques in the energy conversion areas, in a manner which emphasizes the comparative merits of the various technologies without including a large mass of detailed engineering data.

Fuel Cells—A Technical and Economic Study. A. M. Moos. *SAE Natl. Aero Meeting, New York, Apr. 5–8, 1960, Preprint 159D.* 6 pp. Discussion of the types of fuel cell systems, and of their military and commercial applications. The power level requirements for such applications are noted.

High Temperature Fuel Cells. E. A. DeZubay. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 159E.* 26 pp. Review of the principles of fuel cells and discussion of the materials suitable for use in a molten carbonate, hydrocarbon-air high temperature cell.

Radar

Optimum Radar Integration Time. J. M. Flaherty and E. Kadak. *IRE Trans., AP Ser.*, Mar., 1960, pp. 183–185. Presentation of an expression which reveals what the optimum integration period is when the radius of the region to be protected and the velocity of the approaching target are known.

Determining Radar Visibility. Nathan Slawsby. *Electronics*, May 6, 1960, pp. 76, 78. Discussion of the calculation of radar effectiveness in the presence of jamming. A chart interrelating the false alarm probability, the visibility factor, and the number of hits per scan is presented.

Simple Calculation Gives Radar's Jamming Susceptibility. Simon Cohen and George Minty. *Space/Aeronautics*, May, 1960, pp. 195, 197–200, 206. Presentation of two approximate "reduction in range" formulas for a radar subjected to noise jamming. Their use and limitations are discussed and their application illustrated. Range versus jamming curves and polar plots of susceptibility are given.

A Theory of Radar Scattering by the Moon. T. B. A. Senior and K. M. Siegel. *J. Res., Sect. D - RP*, May-June, 1960, pp. 217–229. 25 refs. Presentation of a theory in which the moon is regarded as a "quasi-smooth" scatterer at radar frequencies. A scattered pulse is then composed for a number of individual returns, each of which is provided by a single scattering area. In this manner, it is possible to account for all the major features of the pulse, and the evidence in favor of the theory is presented.

A Multipurpose Radar Target. J. W. Carr. *IRE Trans., AP Ser.*, Jan., 1960, pp. 7–10. Description of a low-voltage, low-energy battery-powered device which uses crystals as switching elements for moving-target simulation by making a mechanically stationary target appear to be moving.

Resistors

High Temperature, General Purpose, Fixed Resistors. W. F. Ebling, Jr., and H. D. Pugh. *USAF WADC TR 60-131*, Feb., 1960. 50 pp.

Semiconductors

Adsorbtsionnye Izmeneniia Poverkhnostnoi Provodimosti Germaniia. V. I. Fistul' and D. G. Andrianov. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 374–376. In Russian. Study of the adsorptive changes in the surface conductivity of germanium and presentation of experimental results.

Telemetry

Telemetry Transmitter for Radiation Satellite A. J. Fisher, W. R. Talbert, and W. R. Chittenden. *Electronics*, May 6, 1960, pp. 68, 69. Description of a disc-shaped telemetry transmitter incorporating a new phase modulator circuit based on a modification of conventional bridged T network. The complete circuit for the transmitter is described.

Transmission Lines

Interaction Impedance Measurements by Propagation Constant Perturbation. P. R. McIsaac and C. C. Wang. *IRE Proc.*, May, 1960, pp. 904–911. 13 refs. Investigation of the perturbation in the complex propagation constant of a lossy, nonreciprocal, periodic wave guide produced by the insertion of a rod, which may be cylindrical or periodic, parallel to the wave-guide axis. The application to the experimental determination of the interaction impedance and electromagnetic field distribution of wave guides is presented together with approximations which are applicable. Explicit interaction impedance relations for three classes of circuits in terms of the phase constant perturbation, caused by a cylindrical or periodic rod, are given.

Bounds on the Elements of the Equivalent Network for Scattering in Waveguides. I—Theory. II—Application to Dielectric Obstacles. Larry Spruch and Ralph Bartram. *J. Appl. Phys.*, May, 1960, pp. 905–917. 18 refs. USAF-supported research.

Symmetric Electric Oscillation of an Ideally Conducting Hollow Cylinder of Finite Length. P. L. Kapitsa, V. A. Fok, and L. A. Vainshtein. (*Zhurnal Tekh. Fiz.*, Oct., 1959, pp. 1188–1205.) *Sov. Phys. - Tech. Phys.*, Apr., 1960, pp. 1088–1105. Translation. Analysis of electromagnetic oscillations in which the current flows along the cylinder and is distributed uniformly over its periphery. An exact integral equation is formulated to relate the vector potential at the surface of the cylinder with the current for any method of excitation of the oscillations, and techniques are presented for its solution. A comparison is made between the proposed method of calculation and the theory of thin antenna radiators.

Development of High Altitude Waveguides. Henry Zucker, Ch. M. Knop, and Kurt Gutfreund. *USAF WADC TR 59-741*, Feb., 1960. 105 pp. 10 refs.

Solid-State Logical Transducers. F. E. Battocletti, E. C. Orris, A. C. Thomas, C. E. Warren, and M. O. Thurston. *USAF WADC TR 59-686*, Feb., 1960. 33 pp. 12 refs. Discussion of theoretical and experimental investigations of methods for performing complex logical operations with semiconductor devices. It is shown that every n-ary connective may be constructed from, at most, two $(n-1)$-ary connectives and a single-pole double-throw switch.

Wave Theory

Patterns of a Radial Dipole on an Infinite Circular Cylinder: Numerical Values. C. A. Levis. *IRE Trans., AP Ser.*, Mar., 1960, pp. 218–222. USAF-sponsored research.

Anomalies in the Absorption of Radio Waves by Atmospheric Gases. A. W. Straiton and C. W. Tolbert. *IRE Proc.*, May, 1960, pp. 898–903. 22 refs. ONR-sponsored summarized presentation of recent measurements of the attenuation of radio waves by atmospheric gases. The measured losses are compared with those predicted by Van Vleck, and the various factors which may influence the discrepancies are discussed.

Signal Transmission Through Ionized Media. W. A. Greenhow. *Electronics*, May 20, 1960, pp. 81–85. Discussion of the ionization processes and their effects on signal transmission. Ionization effects produced by nuclear vehicles, hypersonic re-entry vehicles, rocket motor exhausts, and nuclear explosions are studied.

High-Frequency Diffraction of Electromagnetic Waves by a Circular Aperture in an Infinite Plane Conducting Screen. S. R. Seshadri and T. T. Wu. *IRE Trans., AP Ser.*, Jan., 1960, pp. 27–36. USAF-supported research.

On the Calculation of the Departures of Radio Wave Bending from Normal. B. R. Bean and E. J. Dutton. *J. Res., Sect. D - RP*, May-June, 1960, pp. 259–263. 22 refs. Analysis of non-normal tropospheric bending of radio waves in terms of a reduced-to-sea-level value of the refractive index. The presented method emphasizes departures of bending from the average bending for the United States and consists of visualizing ray bending as composed of two parts: an "average" component and a "departure-from-average" component.

Scintillations of the 20 Mc/s Signal from the Earth Satellite 1958 δ II. J. Frihagen and J. Trøim. *J. Atmos. & Terrestrial Phys.*, No. 1, Apr., 1960, pp. 75–78. USAF-sponsored presentation of the results of a study of scintillations produced in the F-region and in the E-region, as recorded at Kjeller 60°N, 11°E.

On the Mode Theory of Very-Low-Frequency Propagation in the Presence of a Transverse Magnetic Field. D. D. Crombie. *J. Res., Sect. D - RP*, May-June, 1960, pp. 265–267.

Conditions for the Persistence of Purely Longitudinal or Purely Transverse Propagation. W. C. Hoffmann. *J. Atmos. & Terrestrial Phys.*, No. 1, Apr., 1960, pp. 1–7. Presentation of an analysis, based on the appropriate form of the Haselgrove equations for ray-tracing in an inhomogeneous anisotropic medium, of the conditions for radio waves to propagate through the ionosphere exactly parallel or exactly transverse to the local direction of the centered-dipole-magnetic field.

A Theory of Wavelength Dependence in Ultra-high Frequency Transhorizon Propagation Based on Meteorological Considerations. Ralph Bolgiano, Jr. *J. Res., Sect. D - RP*, May-June, 1960, pp. 231–237. 24 refs. USAF-supported presentation of a new model for the structure of refractive index fluctuations induced by turbu-

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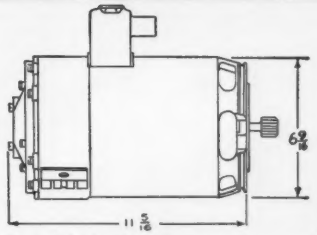

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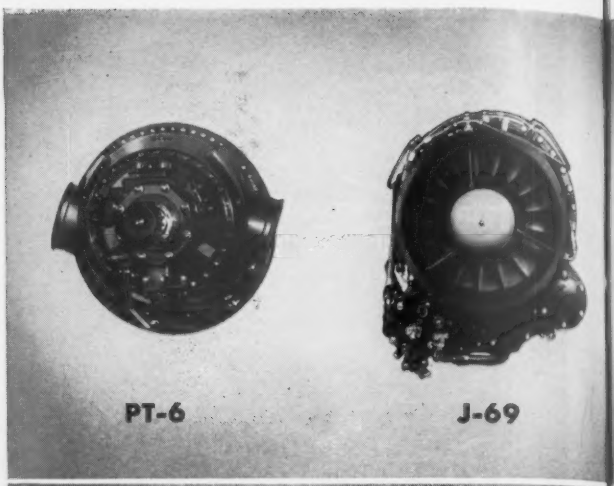

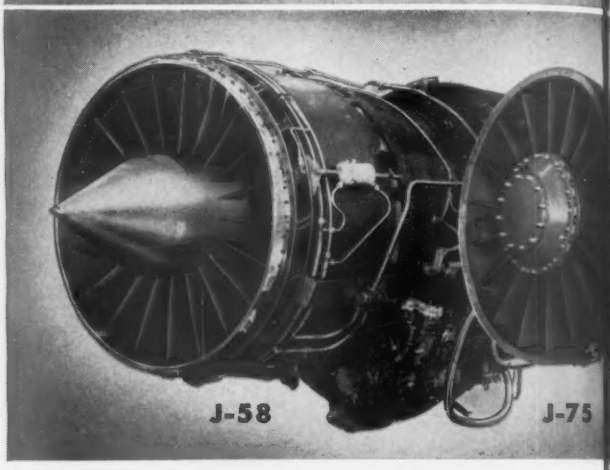

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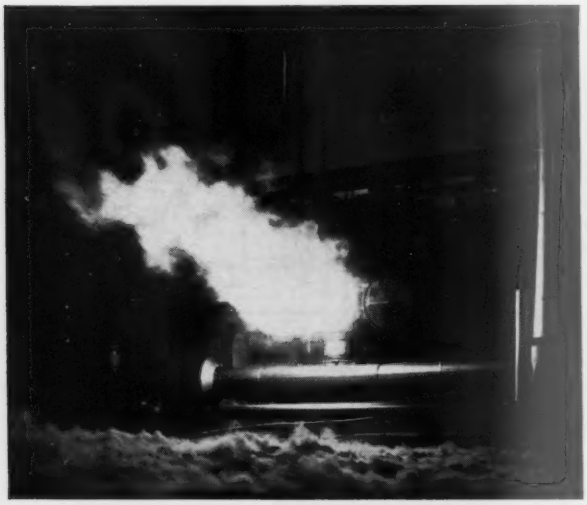

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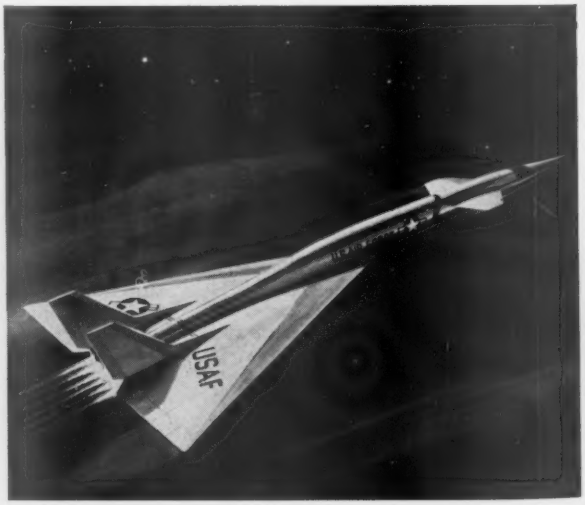

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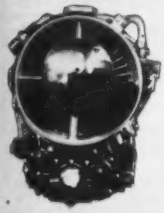
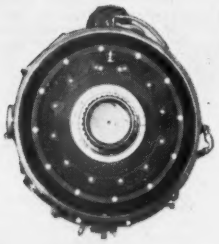
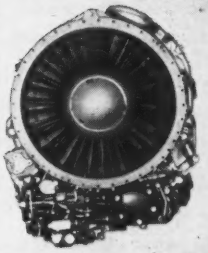


T-58



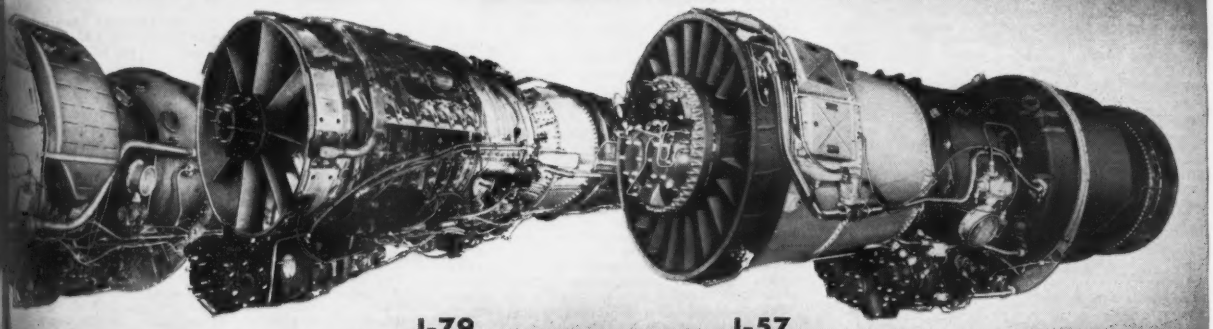
T-55

T-64



J-60

LARGE JETS



J-79

J-57

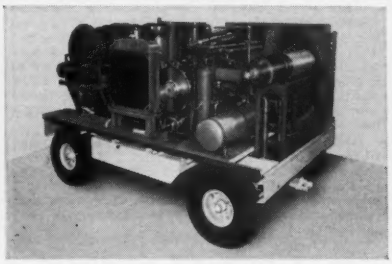
HAMILTON STANDARD

DIVISION OF UNITED AIRCRAFT CORPORATION

WINDSOR LOCKS, CONNECTICUT

SOME OF THE MANY FIELDS OF GROWTH AT HAMILTON STANDARD

ENVIRONMENTAL CONDITIONING SYSTEMS for space vehicles and such advanced aircraft as the B-58, 880, B-70 are important aspects of Hamilton Standard diversification.



GROUND SUPPORT EQUIPMENT. Hamilton Standard is presently producing a wide range of GSE for both missiles and aircraft—from special tools to complete systems.

ELECTRONICS at Hamilton Standard includes broad experience in flight control, instrumentation, static power inversion and electrical control for aircraft, missile and GSE components.

lence, which provides an explanation for the observed distribution of wavelength dependence.

On the Theory of Reflection of Low- and Very-Low-Radiofrequency Waves from the Ionosphere. J. R. Johler and L. C. Walters. *J. Res., Sect. D - RP*, May-June, 1960, pp. 269–285. 13 refs.

Aircraft Scintillation Spectra. R. B. Muchmore. *IRE Trans., AP Ser.*, Mar., 1960, pp. 201–212. Investigation of the spectra of the reflection signals, using the model of aircraft reflection developed by DeLano. Spectra for the amplitude of the rectified return, for the angular fluctuation signal associated with a fixed radar line-of-sight (effective radar center fluctuation), and for the angular fluctuation signal associated with a zero-time constant servo (apparent radar center fluctuation) are derived.

Backscattering from a Finite Cone. J. B. Keller. *IRE Trans., AP Ser.*, Mar., 1960, pp. 175–182. 17 refs. USAF-sponsored calculations, based on the geometrical theory of diffraction, of backscattering for an acoustic wave incident on a hard or soft finite cone, and for an electromagnetic wave incident on a perfectly-conducting finite cone. Two shapes of cone are treated, one with a flat base and the other with a rounded one, and suggestions for shaping an object to minimize its backscattering are given.

Radio Star Scintillation and Multiple Scattering in the Ionosphere. D. S. Bugnolo. *Columbia U. Sch. Eng. Dept. Elec. Eng. TR T-5/D (AFOSR TN 60-451)*, Apr. 1, 1960. 30 pp. 10 refs. Study of recent experimental evidence of radio star scintillation indicating that multiple scattering effects are of importance in the ionosphere. The transport equation is applied to determine the photon density function for this problem. The solution is used to predict the mean squared scattering angle and corresponding size of the ionospheric irregularities as measured on the earth.

The Multiple Scattering of Waves by Weak Random Irregularities in the Medium. I. D. Howells. *Royal Soc. (London) Philos. Trans., Ser. A*, May 5, 1960, pp. 431–462. 22 refs. Extension of the works of Lighthill and Fejer using the equation of energy transfer for radiation in a uniform scattering atmosphere to describe the variation of average intensity in a randomly inhomogeneous medium.

Equipment

Gas Springs Isolate Vibration. A. E. Schmidlin and H. A. Poole, Jr. *Appl. Hydraulics & Pneumatics*, May, 1960, pp. 136, 138, 139. Discussion of the design of gas springs capable of absorbing a large range of frequencies and of compensating for wide variations in g loadings. The performance is analyzed and the gas spring is compared with a pneumatic spring.

Electric

The Electra Electric System. II. *Lockheed Field Serv. Dig.*, Sept.-Dec., 1959, pp. 4–31. Discussion of the total electric system and of the various functional systems which depend on it for power, emphasizing the generation and bus transfer systems. The system layout and circuitry are included.

Selecting the Right Solenoid. E. A. Scutari. *Prod. Eng.*, May 23, 1960, pp. 50–53. Discussion of the function, operation, and selection of a.c. and d.c. solenoids of both linear and rotary types.

A 600°F Airborne Electrical System. J. J. Pierro. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 102V*. 24 pp. Discussion of the HOTELEC project, aimed at developing the major components of an airborne generation and distribution system capable of operating successfully in a 600°F. ambient temperature by 1962. Program objectives, the approaches taken to achieve these, and the material, subcomponents, and component developments achieved to date are studied.

Hydraulic & Pneumatic

A 600°F Hydromechanical Constant Speed Drive. E. W. Kruger and S. S. Baits. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 102T*. 11 pp. Discussion of the design, construction, and qualification testing of a complete paralleled drive system suitable for aircraft use.

Brazed Joints, Thin-Wall Tubing Streamline B-70 Plumbing. *Space/Aeronautics*, May, 1960, pp. 75, 78, 80–90 (ff.).

Fuels & Lubricants

Exergie des Combustibles. Zoran Rant. *Strojniški Vestnik*, No. 6, 1959, pp. 1–4. In French. Discussion covering the determination of exergy of various fuels and fuel mixtures, including solid, liquid, and gaseous types.

An Appraisal of Synthetic Lubricants in Aircraft Gas Turbines. J. P. Perry. (*CAI Mid-Season Meeting, Edmonton, Feb. 19, 1960.*) *Can. Aero. J.*, May, 1960, pp. 156–163. Review of the historical development of ester base synthetic oils in the light of changing engine requirements. Lubrication system requirements, lubricant selection and evaluation, operational experience with respect to different engine types, and the effect of the synthetic oil on materials are discussed. The review covers the period from the introduction of the Viscount in 1953 to the end of the first year's operation of the jet transports.

Recent High Temperature Bearing Developments. J. H. Johnson. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 176A*. 9 pp. Investigation of the performance of bearings submerged in Oronite 8200 hydraulic fluid at 450°F. to determine the magnitude of derating required from AFMBA calculated values and to establish a measure of bearing reliability under the specific conditions of operation.

Analysis of Problems of Oil Film Lubrication for Bearings Under Space Conditions. Ch. M. Apt and N. M. Widerhorn. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 742*. 20 pp. Study of problems encountered in the lubrication of a motor-gear train assembly in space. Primarily considered are the mechanisms of oil losses from bearing surfaces. These include: loss by evaporation from within the housing containing the bearings to space through any openings in the housing; loss of oil from bearing surfaces within the housing to the housing walls by distillation processes; loss of oil by creepage along shafts and walls from within the housing to outside the housing, and subsequent evaporation into space.

Izmerenie Tolshchiny Smazochnykh Sloev. A. A. Kut'kov. *Izmer. Tekh.*, Oct., 1959, pp. 11–13. In Russian. Description of a device designed to measure the thickness and resistance of lubricating films.

Ploskaia Zadacha Gidrodinamicheskoi Teorii Gazovoi Smazki. A. I. Snopov. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 14–20. In Russian. Development of a method for solving the two-dimensional linearized problem in the theory of gas lubrication. The method allows a solution of desired accuracy to be obtained, and the derived formulas are applicable to the case of bearings with random eccentricity.

K Voprosu ob Ustoichivosti Viazkoi Plenki na Tverdom Tele v Potoke Gaza. A. A. Zaitsev. *AN SSSR Dokl.*, Feb. 21, 1960, pp. 1228–1231. In Russian. Study of the stability of a viscous film on a solid body in a flow of gas. The velocity distribution in the liquid film is linear, and the solution for sufficiently small parameters ϵ and σ reduces to that of the partial Orr-Sommerfeld equation.

The Combustion of Elemental Boron. C. P. Talley and L. E. Line, Jr. *Naval Res. Rev.*, Apr., 1960, pp. 16–20. Description of the technique, rate-limiting processes, and the mechanism of boron combustion.

Polymerization of Solid Propellants. W. H. Groetzinger, III. *ARS J.*, May, 1960, pp. 498, 499. Army-sponsored analysis considering heat-transfer and polymerization during curing in simple, one-dimensional, solid propellant grains with constant thermal properties. Attention is given to polymer fraction as well as to temperature, and the nature of the polymer fraction distribution is discussed.

Instruments

Gewichtseinsparung und Zuverlässigkeitserhöhung bei Bordgeräten. *Luftfahrttechnik*, Mar. 10, 1960, pp. 82–85. In German. Survey of the research done in electronic industry in order to save weight and improve reliability of airborne equipment. Illustrative examples are presented, covering a method for manufacturing wave-guide circuits by milling from solid metal blocks, and the application of wrapped joints for wiring electronic equipment.

Solving Pickup Problems in Electronic Instrumentation. Will McAdam and David Vandeventer. *ISA J.*, Apr., 1960, pp. 48–52. Presentation of a logical step-by-step approach to the detection of pickup symptoms, and discussion of pickup origin and methods for preventing its occurrence.

Měření Některých Mechanických Veličin Elektrickou Cestou. Jiří Černohorský. *Zpravodaj VZLÚ*, No. 2, 1959, pp. 31–40. In Czech. Description of methods and instruments for measuring vibrations in reciprocating aircraft engines, as well as torsional oscillations of crankshafts. Also covered are combustion pressures, propeller blade stresses, and airframe measurements.

Obobshchennaia Gidrodinamicheskaia Teoriia Ul'trazvukovogo Interferometra. I. I. Ol'khovskii. *AN SSSR Dokl.*, Feb. 1, 1960, pp. 747–750. In Russian. Derivation of a generalized ultrasonic interferometer theory in the approximation taking into account the heat conductivity of the gas and the boundary.

Accelerometers

Shock Testing Instrumentation. I. Maxwell Lazarus. *Environmental Quart.*, Apr., 1960, pp. 14–17, 46. Discussion of the limitations of unbonded strain gage accelerometers and diode tube accelerometers, and description of crystal accelerometers with improved low frequency response.

Flight Instruments

Pilot Instrumentation for Vehicle Control in Near Space. C. J. Hecker. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 173C*. 8 pp. Brief description of the three phases of flight: escape, exo-atmospheric, and recovery. The instrumentation requirements for the pilot during these phases are also covered.

Flow Measuring Devices

Accurate Measurement of Flow Rates; Description of the de Havilland Pottermeter. *Aircraft Eng.*, May, 1960, p. 145.

Heat Transport Anemometer of High Stability. A. J. Dyer. *J. Sci. Instr.*, May, 1960, pp. 166–, 169. Description of an anemometer based on the principle of detecting the wake behind a heated wire by means of a thermometric bridge. The new principle combines the advantages of an earlier model, linearity and unidirectivity, with an amplifier gain of 80 times with a corresponding improvement in stability and simplicity.

Theory of the Stagnation-Point Langmuir Probe. Lawrence Talbot. (*U. Calif. Inst. Eng. Res. Ser. 132/11 TR HE-150-168*, Mar. 30, 1959.) *Phys. Fluids*, Mar.-Apr., 1960, pp. 289–298. 20 refs. AFOSR-supported research.

Gyroscopes

On the Equations of the Precessional Theory of a Gyroscope in the Form of Equations of Motion of the Pole in the Phase Plane. A. Iu. Ishlinskii. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 801–809.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1153–1163. Translation.

A Particular Solution of the Problem of the Motion of a Gyroscope on Gimbals. A. A. Bogoiavlenskii. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 958–960.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1365–1369. Translation. Investigation of a solution for the problem of motion of a heavy gyroscope on gimbals, for the case in which the axis of rotation of the outer ring is horizontal.

Investigation of the Stability of a Gyroscope Taking Into Account the Dry Friction on the Axis of the Inner Cardan Ring (Gimbal). V. V. Krementulo. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 968–970.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1382–1386. Translation.

The Theory of a Gyrocompass. V. N. Koshliakov. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 810–817.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1164–1173. Translation. Investigation of the equations of the perturbed motion of a gyrocompass with two rotors, which does not have the properties of the space (free) gyrocompass of Geckeler-Anschutz.

Ceramic Gyroscope Uses Gas Bearings. P. J. Klass. *Av. Week & Space Tech.*, June 6, 1960, pp. 81, 83, 85. (Also in *Missiles & Rockets*, June 6, 1960, pp. 22, 23.) Presentation of design features of a new miniature integrating gyro which uses a spinning rotor made of ceramic and supported in gas bearings, which cuts the gyro drift rate by a factor of 10:1.

The Swing to Tilt-Devices for Gyro Testing. G. E. Sonntag and J. L. Perample. *Aircraft & Missiles*, June, 1960, pp. 34–36. Presentation of a test method using the earth's gravity vector for precise acceleration inputs.

Recording Equipment

High Density Digital Magnetic Recording Techniques. A. S. Hoagland and G. C. Bacon. *IRE Trans., EC Ser.*, Mar., 1960, pp. 2–11. Discussion of the justification of readback waveform synthesis through "single pulse" superposition. A comprehensive, yet general, readback simulation program is described which will automatically, for any characteristic pulse, simulate all possible readback signal patterns and test them for specified reading logic as a function of bit density.

Primenenie Magnitnoi Zapisi dlia Ostsillografirovaniia Infranizkochastotnykh Protsessov. V. A. Nosov. *Izmer. Tekh.*, Nov., 1959, pp. 33–35. In Russian. Description of a device using ferromagnetic tape for recording static and dynamic processes by means of wire, induction, and semiconductor gages.

Stress & Strain Measuring Devices

Torsiometr Povyshennoi Tochnosti. A. V. Gur'ev. *Izmer. Tekh.*, Sept., 1959, pp. 30, 31. In Russian. Description of a highly sensitive instrument for measuring the deformation of materials subjected to loading.

12-Kanálová Tenzometrická Souprava. Jindřich Tvrdý. *Zpravodaj VZLÚ*, No. 2, 1959, pp. 41, 42. In Czech. Description of a 12-channel tensometer designed for static-dynamic measurement of stresses in aircraft landing gear.

Publications abstracted may be borrowed from the IAS Library. In making inquiry, please mention the month of *Aerospace Engineering* in which the abstract appeared. This will facilitate servicing of requests.

Fóliové Odporové Tensometrické Snímače. L. Tomanec. *Jemná Mech. & Optika*, Apr., 1960, pp. 112–115. In Czech. Study of the characteristics of foil strain gages and comparison with those of wire strain gages. Results of stability measurements are given and the manufacturing process is described.

Tachometers

Drag Cup Tachometer Design. Ed Hlipala. *Kearfott Tech. News Bul.*, Jan.-Feb., 1960, pp. 3-5, 8, 10. Discussion of some problems encountered in the design of drag cup tachometers, particularly those involving the selection of materials.

Temperature Measuring Devices

Basic Studies on Base-Metal Thermocouples. J. F. Potts, Jr., and D. L. McElroy. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 158A.* 12 pp.

Development of High-Temperature Thermocouple-Materials. R. C. Lever. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 105V.* 12 pp. 17 refs. Discussion of the present status of thermocouple materials. Information pertaining to their ultimate high-temperature measurement capability is reviewed.

How Reliable Are the Two New High-Temperature Thermocouples in Vacuum? F. W. Kuether and J. C. Lachman. *ISA J.*, Apr., 1960, pp. 67–71. Presentation of initial calibration data and of data on the stability of thermal emf of rhodium-iridium/iridium and tungsten/rhenium thermocouples. An evaluation of these couples shows that the rhodium-iridium/iridium pair promises to be highly useful in oxidizing atmospheres from 3,000° to 3,600°F., and that the tungsten/rhenium couple is an excellent combination for use in other than oxidizing atmospheres well into the 4,000° to 5,000°F. range.

Intercomparison of Thermocouple Response Data. F. R. Caldwell, L. O. Olsen, and P. D. Freeze. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 158F.* 32 pp. Review of the factors affecting the magnitude of the time constant of an immersion-type sensor, specifically, a chromel-alumel thermocouple. A simplified approximate correction for the effects of radiation on the time constant is presented.

Dynamic Testing of Gas Sampling Thermocouples. J. D. Meador. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 158G.* 11pp. Discussion of the performance characteristics of gas sampling thermocouples used in the Allison Model 501 engine. Various environmental factors affecting the performance of the thermocouples are analyzed, and criteria are established for the testing of such components.

A Heated Hypersonic Stagnation-Temperature Probe. R. D. Wood. *J. Aero/Space Sci.*, July, 1960, pp. 556–558. Army-sponsored description of the probe, discussion of heat losses, and presentation of the method of calibration.

Resistance-Temperature Relationship of Platinum at Low Temperatures and Its Influence on Precision Thermometry. G. C. Lowenthal and A. F. A. Harper. *Brit. J. Appl. Phys.*, May, 1960, pp. 205–208. 28 refs.

Vysokotemperaturnye Poluprovodnikovye Termopary. P. S. Kislyi and G. V. Samsonov. *AN SSSR Otd. Tekh. Nauk Isv. Metall. i Toplivo*, Nov.-Dec., 1959, pp. 133–137. 16 refs. In Russian. Discussion of the requirements of high-temperature semiconducting thermocouples and description of experiments made to determine the applicability of certain refractory materials in the fabrication of thermocouple electrodes.

A Stable High Temperature Thermometry Rig. R. J. Moffat. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 158E.* 14 pp. Description of an apparatus for testing bare wire and complex thermocouple probes, producing a gas stream which is stable and uniform over a wide range of conditions. The means of removing the fluctuations and gradients, and the instrumentation useful in the study of thermocouple behavior, are discussed.

Time Response Characteristics of Temperat re Sensors. M. D. Scadron. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 158H.* 9 pp. Discussion of the "time constant" of the sensor and of its dependency upon the mass (or size) of a given sensor and the mass velocity of the fluid or gas in which it is immersed.

A Design Procedure for Thermocouple Probes. L. B. Haig. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 158C.* 23 pp. 10 refs. Presentation of an analytical procedure for the design of thermocouple probes for the accurate measurement of gas temperatures under steady state conditions. The procedure is illustrated by the design of a probe for measuring gas temperature in the range of 100°F. with an error limit of 0.2°F. at Mach numbers ranging from 0.2 to 1.0. Test results substantiating this design procedure are included.

Laws & Regulations

Problemi Giuridici della Navigazione Spaziale. Amedeo Giannini. *Riv. Aero.*, Oct., 1959, pp. 1839–1856. In Italian. Discussion of the legal aspects of space navigation.

Lighter-Than-Air

The Nuclear Powered Airship. Leo Jurich. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 169A.* 7 pp. Discussion covering the design proposal for a nonrigid nuclear-powered airship. The major advantages of such an airship are the low power required for propulsion and the separation distance available between crew members and the reactor.

Machine Elements

Bearings

Development Progress on Gas Bearings for Airborne Accessory Equipment. C. R. Adams. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 176C.* 13 pp. Discussion of the types of gas bearings and their applications. Externally pressurized gas bearings require careful attention to design for each particular application. The step bearing seems promising because of its simplicity and ease of manufacture.

NASA Research on the High-Temperature Bearing Problem. W. J. Anderson and E. E. Bisson. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 176D.* 18 pp. 25 refs. Review of various approaches to the high-temperature bearing problem, and discussion of the research which has been completed or is at present being done by the NASA in this field.

Recent Developments in High Temperature Bearings and Lubricants. P. C. Hanlon. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 176B.* 44 pp. 15 refs. Review of research on rolling element bearings and their lubricants for operation at temperatures from −65° to 1,200°F. It is concluded that bearing materials are available which will give satisfactory service over the temperature range desired.

K Teorii Vozdushnykh Podvesov Sfericheskogo Tipa. Ia. M. Kotliar. *AN SSSR Otd. Tekh. Nauk Isv. Mekh. i Mashinostr.*, Nov.-Dec., 1959. pp. 21–26. In Russian. Development of the theory of air lubricated ball bearings.

Recent Advances in Ball and Roller Bearings. T. H. Cooper. (*CAI Mid-Season Meeting, Edmonton, Feb. 20, 1960.*) *Can. Aero. J.*, May, 1960, pp. 164–169.

Einbau und Belastbarkeit von Flugwerklagern. G. Hentschel. *Luftfahrttechnik*, Dec. 15, 1959, pp. 406–410. In German. Survey of current design methods for aircraft bearings, and definition of the terms "safe static load" and "safe dynamic load with oscillatory movement." Future possibilities are discussed on the basis of laboratory results.

Fastenings

Development and Application of Fatigue Analysis to Aircraft Fasteners. J. L. Chinn. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 108T.* 11 pp. Presentation of the features covered by the final fatigue test specifications: test machines, specimen holding fixtures, standard fatigue test nuts, the test set-up, test loads and conditions, test reports, and inspection requirements of fatigue test specimens. A comparative evaluation of alloy titanium and steel fasteners, and new developments in fatigue test methods and equipment are included.

Friction

Friction and Wear at Elevated Temperatures. Ernest Rabinowicz. *USAF WADC TR 59-603*, Jan., 1960. 21 pp. 11 refs.

Transmissions, Clutches, Drives

600°F Constant Speed Drives—Mechanical Traction Type. C. D. Flanigen. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 102U.* 18 pp. Discussion of the design and development of a 600°F. mechanical traction type constant speed drive. The choice of ...mate-

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rials and thermally stable ubricants which are compatible at 600°F. and the problem of electronic components operating at 600°F. are studied.

Breakthrough in Mechanical Drive Design: The Harmonic Drive. C. W. Musser. *Mach. Des.*, Apr. 14, 1960, pp. 160–173. Presentation of the complete design details of the drive, its operating principles, performance characteristics, design alternatives, and application possibilities.

Maintenance

Considerations in Prediction of Maintainability. R. G. Lowder. *USAF WADC TN 59-378*, Nov., 1959. 7 pp. Presentation of a method for predicting how much maintenance will be required by a weapon system before it goes into production. Recommendations are also made for the construction of a predicting instrument.

Comments on the Evolution of Aircraft Maintenance. I. J. Kessler. (*CAI Mid-Season Meeting, Edmonton, Feb. 20, 1960.*) *Can. Aero. J.*, May, 1960, pp. 178–183. Discussion of the factors important in maintenance and of the effective ways to measure, distribute, and control the maintenance resources.

Materials

Werkstoffauswahl für neuzeitliche Flugzeuge. E. A. Green. *Luftfahrttechnik*, Dec. 15, 1959, pp. 400–406. In German. Discussion of requirements to be taken into account in the selection of structural materials for modern aircraft.

Ceramics & Ceramals

Mechanical Property Survey of Refractory Nonmetallic Crystalline Materials and Intermetallic Compounds. W. D. Smiley, L. E. Sobon, F. M. Hruz, E. P. Farley, J. E. Chilton, E. F. Poncelet, and J. J. Kelly. *USAF WADC TR 59-448*, Jan., 1960. 308 pp. 1,201 refs. Survey of the literature on the mechanical properties of nonmetallic polycrystalline compounds and intermetallic compounds with melting points above 1,500°C., including a review of the theoretical concepts of flow and fracture. It is concluded that the mechanical properties of many materials have not been evaluated, and that data from tests closely simulating actual use conditions are necessary.

An Investigation of the Mechanical Properties of Cermets as Related to the Microstructure. Ira Binder. *USAF WADC TR 58-432, Pt. II*, Jan., 1960. 88 pp. Study of the microstructure of TiC/Ni compositions with 10, 20, and 40 per cent nickel at the onset of plastic deformation, in order to investigate the mode of deformation, the plastic flow of the nickel binder, and alignment of the carbide grains. The experiments included transverse bend, hot deformation, hot extrusion, and cantilever beam. Other refractory hard-metal compositions are also investigated.

Dielectric Properties of Alumina at High Temperatures. J. V. Florio. (*Am. Ceram. Soc. 61st Annual Meeting, Chicago, May 20, 1959.*) *Am. Ceram. Soc. J.*, May, 1960, pp. 262–267. 27 refs. Investigation of the dielectric constant and dissipation factor of both single-crystal and polycrystalline alumina, measured in air over the frequency range of 10^2 to 3×10^5 cps, in the temperature range from 900° to 1,300°C.

Transparent Crucible Material for High Temperatures. R. C. DeVries and C. F. Moehle. *Am. Ceram. Soc. Bul.*, May, 1960, pp. 270, 271. Discussion of transparent crucibles fabricated from MgO single crystals and suitable for the observation of such reactions as crystal growth, solidification, or melting in certain systems.

Ceramic Encapsulents. W. R. Cuming. *Electronic Des.*, May 25, 1960, pp. 54, 55. Discussion of the properties of several inorganic bonding agents and inorganic fillers.

Ceramic Bodies and Coatings for Rocket Engine Applications. W. T. Monagle. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 168B.* 8 pp. Review of the applications of ceramic bodies and coatings to the solution of the rocket motor problems.

Corrosion & Protective Coatings

Surface Protection. *de Havilland Gazette*, Apr., 1960, pp. 48, 49. Survey of protective treatments for aluminum-alloy propeller blades. These treatments are also likely to prove of value to compressor blades and other components where protection is required against erosion, abrasion, and corrosion.

You Can Get a Harder Anodize. J. E. Trankla. *Aircraft & Missiles*, June, 1960, pp. 48, 49. Presentation of the properties of the tough oxide coat produced by hard anodizing on aluminum. Wear, corrosion, and heat resistance of aluminum are shown to be improved.

Further Investigation of the Effects of Molten Boron Oxide on High Temperature Materials. J. W. Rosenbery. *USAF WADC TR 59-205*, Jan., 1960. 92 pp. 11 refs.

Effect of Boron Containing High Energy Fuel Combustion Products on the Properties of Statically Stressed High Temperature Alloys. G. L. Vonnegut and William Mahler. *USAF WADC TR 59-317*, Jan., 1960. 61 pp. Presentations of details concerning the development and operation of test apparatus, and results of the metallurgical evaluation to determine the effects of boron-containing (TMBO-TMBA) high-energy fuel combustion products on the stress rupture behavior and structures of representative nickel, cobalt, and molybdenum base high-temperature alloys.

Mekhanizm Obrazovaniia Perekisi Vodoroda pri Korrozii Metallov. T. M. Abramova, I. L. Gankina, and A. S. Fomenko. *AN SSSR Dokl.*, Dec. 1, 1959, pp. 820–823. 16 refs. In Russian. Description of experiments made on several metals to study the mechanism of hydrogen peroxide formation during corrosion.

High Temperature

Refractory Materials. II—High-Temperature Behavior. R. I. Jaffee and D. J. Maykuth. *Aero/Space Engrg.*, July, 1960, pp. 39–44. 45 refs. Discussion of the mechanical behavior of refractory materials at elevated temperatures and of the physical properties important in controlling thermal stresses developed in structural applications. Future trends for these materials are also suggested.

Mechanical Properties of Selected Alloys at Elevated Temperatures. II—Design Criteria of Silicon Carbide. H. A. Pearl, J. M. Nowak, and H. G. Deban. *USAF WADC TR 59-702, Pt. II*, Mar., 1960. 121 pp. 38 refs.

Structural and Insulative Characteristics of Ablating Plastics. F. A. Vassallo, N. E. Wahl, G. A. Sterbutzel, and J. L. Beal. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 168C.* 17 pp. Presentation of temperature profiles within plastics as a function of time and their correlation with analytic expressions. The strength of the residual plastic, measured during ablation, is expressed by an empirical relation; the temperature rise of a metal at the rear face of the plastic is measured and correlated with an analytic expression; effective heats of ablation and ablation temperatures are measured; and the degradation of the materials is examined after ablation.

Materials for High (2500°-4000°F) Gas Engine Temperature Measurements. A. R. Anderson and D. J. MacKenzie. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 158B.* 11 pp. 27 refs. Discussion of the state of materials available for use as thermocouples, including thermoelements and lead wire, insulation materials, and sheath materials.

O Strukture i Fazovom Sostave Diffuzionnogo Pokrytiia Niobiia Kremniem. P. M. Arzhanyi, R. M. Volkova, and D. A. Prokoshkin. *AN SSSR Otd. Tekh. Nauk Izv. Metall. i Toplivo*, Nov.-Dec., 1959, pp. 127–129. In Russian. Presentation of experimental results obtained from the study of the structure and phase composition of niobium, diffusion coated with silicon.

Evaluation of Ablation Materials for High Temperature Application. M. A. Schwartz, W. Bandaruk, and G. J. Mills. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 98T.* 10 pp. Presentation of an ablation testing technique employing an oxyacetylene torch. Desirable properties in ablation materials for ultra-high temperature applications and representative test results are described.

Metals & Alloys

Structure and Properties of Rare-Earth and Yttrium Hard Metals. Ira Binder. (*Am. Ceram. Soc. 61st Annual Meeting, Chicago, May 20, 1959.*) *Am. Ceram. Soc. J.*, June, 1960, pp. 287–292. 36 refs. Discussion of the preparation, structures, and properties of rare-earth and yttrium hard metals, with emphasis on borides and silicides.

Boron: Impressive Properties, Impressive Problems. D. N. Williams. *Space/Aeronautics*, May, 1960, pp. 101, 102, 106, 108, 112. Discussion of outstanding problem areas in boron technology. Data on physical, electric, and optical properties are given.

Issledovanie Metallicheskikh Soedinenii v Mnogokomponentnykh Nikelevykh Splavakh, Soderzhashchikh Niobii. R. B. Golubtsova and L. A. Nude. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 318–321. In Russian. Presentation of experimental results obtained from the study of the composition and structure of metallic compounds in multicomponent nickel alloys containing niobium.

Fatigue Fracture. P. J. E. Forsyth and D. A. Ryder. *Aircraft Eng.*, Apr., 1960, pp. 96–99. Discussion of the nature of the microscopic fracture striations and of their use in the diagnosis of fatigue failures. It is shown how they can be used to obtain quantitative information.

On the Brittle Fracture of Structures. P. C. Paris and W. E. Anderson. *Trend in Eng.*, Apr., 1960, pp. 11–14. Discussion of Griffith and Irwin's theories on cracks as applied to ductile materials, and of some of the current trends in fracture analysis. The factors affecting tear resistance are described, and the selection of an alloy for optimum tear resistance is outlined.

Concerning Equilibrium Cracks Forming During Brittle Fracture; the Stability of Isolated Energetic Theories. G. I. Barenblatt. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 893–900.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1273–1282. Translation.

O Kriteriiakh Iznosa Materialov. I. V. Kragel'skii. *AN SSSR Dokl.*, Dec. 11, 1959, pp. 1016–1019. 13 refs. In Russian. Establishment of a criterion for wear determination in materials subjected to friction, including a study of techniques for simulating wear conditions on models.

Vliianie Polarizatsii na Korrozionnoe Rastreskivanie Metallov. V. V. Romanov. *AN SSSR Dokl.*, Dec. 1, 1959, pp. 873–875. In Russian. Study of the effect of polarization on the formation of corrosion cracks in metals.

State of the Art: Columbium and Tantalum. Irwin Stambler. *Space/Aeronautics*, May, 1960, pp. 46–51. 40 refs. Discussion of the mechanical properties of columbium and tantalum. Factors studied include: tensile properties, oxidation resistance, and fabrication.

Studies of Heat-Resistant Alloys. A. P. Coldren, J. E. White, R. K. Bowen, and J. W. Freeman. *USAF WADC TR 59-606*, Feb., 1960. 97 pp. 13 refs. Study of the effects of hot-working on the structure and properties of heat-resistant alloys. The rupture strength and creep are investigated on a commercially pure alloy ("A" Nickel), a precipitation-strengthened austenitic alloy (A–286), and a low-alloy ferritic steel ("17-22-A"V).

An Investigation of Intermetallic Compounds for Very High Temperature Applications. Appendix I, II—**X-Ray Diffraction Powder Patterns.** R. M. Paine, A. J. Stonehouse, and W. W. Beaver. *USAF WADC TR 59-29, Pt. I*, Jan., 1960. 236 pp. 603 refs. Study of the oxidation resistance in dry air at 2, 300°F. of intermetallic compounds from 35 binary metallic systems. Only high-melting (above 2, 550°F.) compounds are investigated, including aluminides, beryllides, silicides, germanides, zirconides, and miscellaneous compounds.

Radiatsionnaia Pirometriia Metallov v Blizko Infrakrasnoi Oblasti Spektra. D. Ia. Svet. *AN SSSR Dokl.*, Jan. 1, 1960, pp. 61–63. In Russian. Discussion of radiation pyrometry of metals in the near infrared region and presentation of results obtained on several metals.

Relaksatsiia Napriazhenii i Polzuchest' kak Protsessy Viazkogo Techeniia. N. S. Fastov. *AN SSSR Dokl.*, Jan. 1, 1960, pp. 64–67. In Russian. Study of the stress relaxation and creep as viscous flow processes in solid bodies, including a description of tests on homogeneous bars subjected to uniaxial tension and evaluation of the discrepancy between theoretical and experimental results.

O Neodnorodnosti Plasticheskoi Deformatsii pri Rastiazhenii. B. M. Strunin. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 310–313. 12 refs. In Russian. Study of the inhomogeneity of plastic deformation in materials subjected to tension.

Kriterii Dlitel'noi Prochnosti dlia Nekotorykh Zharoprochnykh Splavov pri Slozhnom Napriazhennom Sostoianii. V. P. Sdobyrev. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 93–99. In Russian. Presentation of experimental results obtained on certain heat resistant alloys tested under the conditions of compound stressing and subjected to the combined effect of tension and torsion at temperatures of 600°, 700°, and 750°C.

Izmenenie Mekhanicheskikh Svoistv i Mikrostruktury Metallov v Protsesse Polzuchesti. L. K. Gordienko and I. A. Oding. *AN SSSR Otd. Tekh. Nauk Izv. Metall. i Toplivo*, Nov.-Dec., 1959, pp. 52–65. 19 refs. In Russian. Presentation of experimental results obtained on the variation of mechanical properties and microstructure of metals under conditions of stress and high temperature.

K Termodinamike Neobratimykh Protsessov Plasticheskogo Deformirovaniia. N. S. Fastov. *AN SSSR Dokl.*, Jan. 21, 1960, pp. 541–544. In Russian. Study covering the thermodynamics of irreversible processes of plastic deformation.

An Investigation of the Relationship of Hot-Hardness to the Elevated Temperature Extrusion Behavior of Selected Arc-Cast Molybdenum Base Alloys. J. R. Giancola. *USAF WADD TR 59-26*, Feb., 1960. 122 pp. 73 refs.

Oxidation of Tungsten and Tungsten Based Alloys. E. A. Gulbransen, K. F. Andrew, F. E. Blackburn, T. P. Copan, and A. Merlin. *USAF WADC TR 59-575*, Feb., 1960. 78 pp. 48 refs.

K Voprosu o Strukture Linii Skol'zheniia v Staliakh. N. S. Alferova, V. P. Konovalova, and A. I. Rizol'. *AN SSSR Otd. Tekh. Nauk Izv. Metall. i Toplivo*, Nov.-Dec., 1959, pp. 131, 132. In Russian. Study of the structure of slip lines in deformed steel specimens, using an electron microscope.

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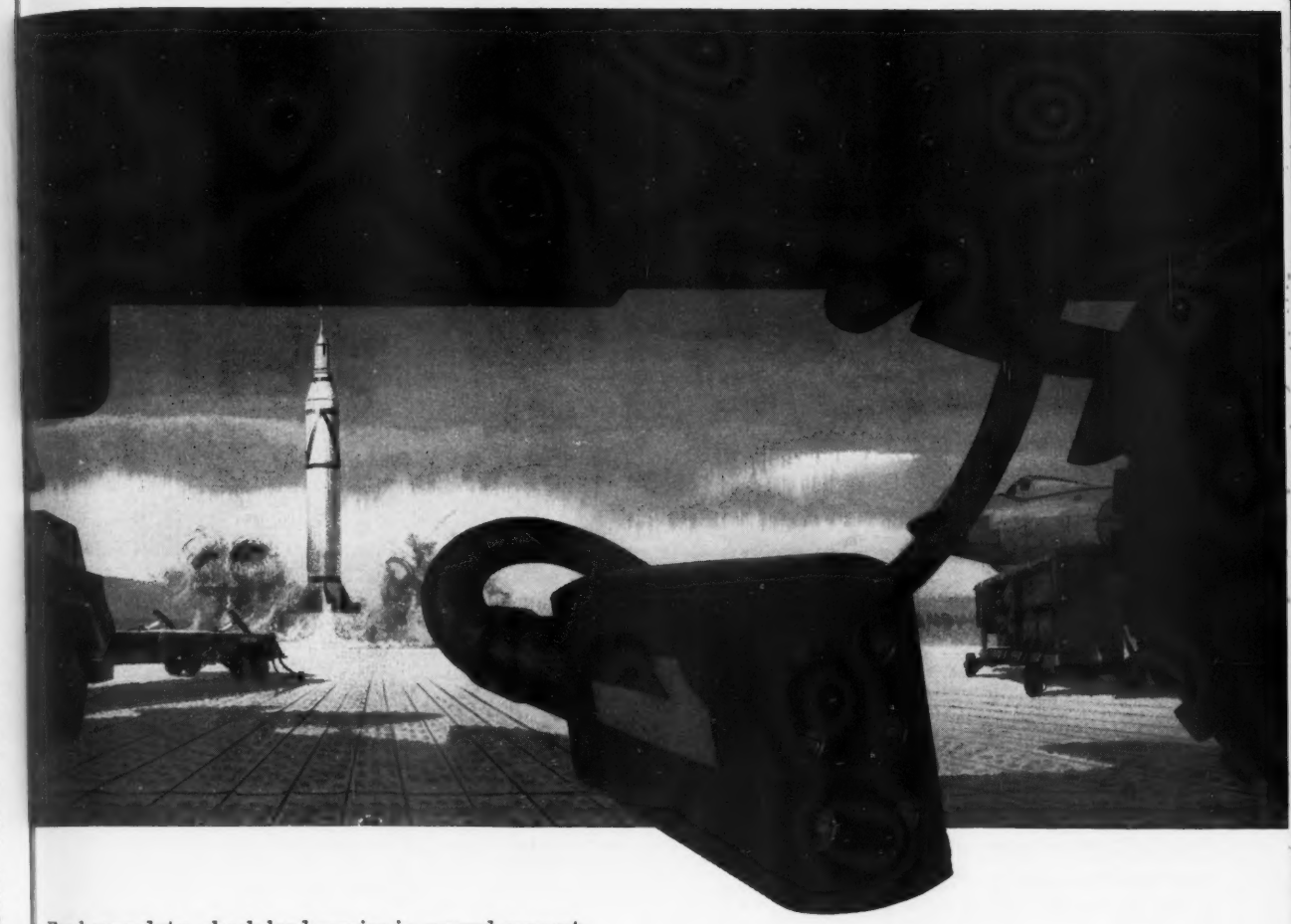

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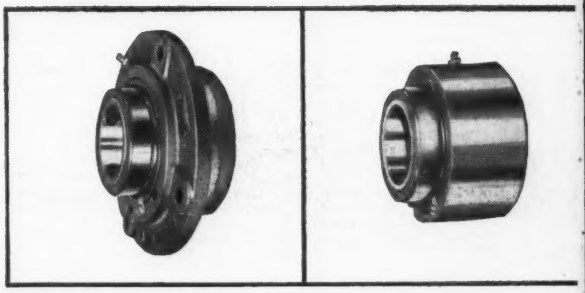

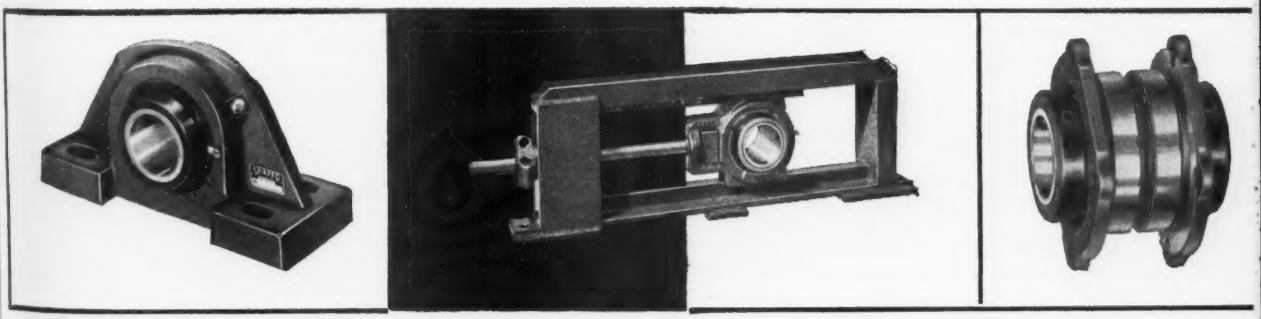

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Metals & Alloys, Nonferrous

A Study of Ternary Phase Diagrams of Tungsten and Tantalum. W. Rostoker. *USAF WADC TR 59-492*, Mar., 1960. 85 pp. 43 refs. Investigation of approximate phase relationships in 36 ternary metal systems based on tungsten and tantalum.

Aluminium and Aircraft Engineering. A. J. Kennedy and A. R. Sollars. *Aircraft Eng.*, Apr., 1960, pp. 100–105. Review of the extent of present alloy development with special attention to alloys of the high-strength precipitation-hardening type.

Factors Influencing the Fatigue Behaviour of Welded Aluminium. J. E. Tomlinson and J. L. Wood. (*Symposium on Fatigue of Welded Structures, Cambridge, Mar. 29—Apr. 1, 1960.*) *Brit. Welding J.*, Apr., 1960, pp. 250–264. 32 refs. Study of the fatigue behavior of aluminum alloys used in welded construction and of the behavior of welded connections. It is shown that for a given material the performance of as-welded joints depends mainly on configuration and bead profile, and that internal defects are of importance in butts where reinforcement is removed. Methods of improving fatigue performance are also discussed.

Recovery of Internal Friction in Aluminum After Plastic Deformation. Ivar Holwech. *J. Appl. Phys.*, May, 1960, pp. 928–931. 20 refs. Measurement by the ultrasonic pulse method of the internal friction in polycrystalline, superpurity aluminum during and after creep under constant load.

Damping Properties of Clad Aluminum. J. G. Kaufman. *Prod. Eng.*, May 23, 1960, pp. 54, 55. Presentation of data on high-strength aluminum alloys clad with pure aluminum. It is shown that a gain of up to 20 times the original capacity to damp vibrational energy can be realized.

Design Criteria for 6Al-4V Titanium Alloy at Room and Elevated Temperatures. M. M. Lemcoe and J. K. Childs. (*USAF WADC TR 58-246*, Aug., 1958.) *ASTM Bul.*, May, 1960, pp. 41–46. 18 refs. Comparison of test results determining tensile, shear, bearing, and compressive properties on both bar and sheet material in the annealed condition at temperatures from 75° to 1,000°F., and tensile properties of sheet material after 100-hour exposure at 600°, 800°, and 1,000°F., with recently established minimum requirements for tensile strength in order to derive design values for strength in compression, bearing, and shear. The resulting design data are presented in tabular form and also in curves showing the effect of temperature on the various properties.

Nonmetallic Materials

Novyi Termostoikii Teploizoliatsionnyi Material "Penosil." I. I. Kitaigorodksii and N. V. Artamonova. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 377, 378. In Russian. Evaluation of the heat-resistant and insulating properties of Penosil and discussion of its development and possible applications.

Analysis of Webbing Impact Data and Determination of Optimum Instrumentation to be Used in Conjunction with the Impacting of Webbing. R. B. Williams and R. J. Benjamin. *USAF WADC TR 59-694*, Mar., 1960. 64 pp.

The Determination of Interlaminar Tensile Strength of Reinforced Plastics. Appendix I—**Details of Materials and Curing Cycles.** Appendix II—**The Derivation and Application of the Interlaminar Stress Equation.** D. J. McCue. *Gt. Brit., RAE TN Chem. 1353*, Aug., 1959. 15 pp. Discussion of a method for assessment of interlaminar strength by measuring the tensile interlaminar stress in a beam whose natural curvature is decreased by end couples. Structural design minimizing this effect under working conditions, suggestions for the use of designs of higher tensile strength, as well as some experimental results are included.

The Influence of the Thickness of the Specimen on the Mechanical Properties in Compression and in 3 Point Bending of Glass Fabric Base Plastic Laminates at Room Temperature. A. Hartman. *Netherlands, NLL TN M. 2033A*, May, 1957. 46 pp.

Influence de la Température sur la Vitesse de Fluage de Certaines Matières Plastiques Transparentes dans le Domaine du Seuil de Transition. A. Kh. Iablokoff and M. Hédiard. *La Recherche Aéronautique*, Nov.-Dec., 1959, pp. 21–36. In French. Study of the effect of temperature on the rate of creep in certain transparent plastic materials, made to determine their behavior under thermal shock. A simple graphical method is presented for calculating the parameters of transparent aircraft parts.

Dynamic Mechanical Properties of High Polymers. L. E. Nielsen. *SPE J.*, May, 1960, pp. 525–531, 533. 40 refs. Discussion of the practical and theoretical importance of dynamic mechanical measurements. The experimental apparatus and the relationship between the dynamic properties and the structure of polymers are studied.

Tragende Flugzeugteile aus glasfaserverstärkten Kunststoffen. Ulrich Hütter. *Luftfahrtechnik*, Feb. 10, 1960, pp. 34–44. 37 refs. In German. Survey of the properties of glassfiber-reinforced plastics, discussion of their current applications, and evaluation of their advantageous characteristics for use in aircraft structural components.

A Guide to Potting and Encapsulation Materials. I—Selection Factors; Seven Types and Their Properties. C. V. Lundberg. *Materials in Des. Eng.*, May, 1960, pp. 123–127. Discussion of the properties of hot melts, styrene-polyesters, epoxies, modified epoxies, silicones, liquid elastomers, and foams, as well as factors to be considered in their selection to fulfill particular requirements.

Testing Methods

Research and Development Leading to the Establishment of Ultrasonic Test Standards for Aircraft Materials. G. L. Cross, R. E. Kleint, and R. D. McKown. *USAF WADC TR 59-466*, Feb., 1960. 138 pp. 10 refs.

Electron Mirror Microscopy in Magnetic and Metallurgical Studies. L. J. Mayer. *USAF WADC TR 59-640*, Oct., 1959. 72 pp. 84 refs.

100,000-atm Pressures Produced for Materials Studies. *Space/Aeronautics*, May, 1960, pp. 93, 94, 96. Description of a compact high-pressure apparatus built by National Bureau of Standards to study material properties. The device can be operated by a conventional hydraulic press and produces pressures of 100,000 atm. A special configuration for studies of electric resistance is also described.

Technique Non Destructive pour les Observations, en Particulier de Nature Métallographique, sur les Surfaces Métalliques. P.-A. Jacquet. *France, ONERA NT 54*, 1959. 48 pp. 47 refs. In French. Description of a nondestructive technique for surface analysis, which is particularly useful for examining areas of incipient fatigue fracture and for the identification of superficial inclusions.

Thin Metal Films as Corrosion Indicators. R. B. Belser and Niels Engel. *USAF WADC TR 59-759*, Mar., 1960. 65 pp. 12 refs.

Rheological Testing of Elastomers at Low Temperatures. II. L. Boor, M. Hanok, F. Conant, and W. Scoville, Jr. *ASTM Bul.*, May, 1960, pp. 25–32. 12 refs. Presentation of the results of a study to determine the extent to which certain superposition principles are applicable to the analysis of different types of deformation of elastomeric materials. Applications of this method of analysis are given to show how the rheological behavior of an elastomer at a given temperature may be predicted for very short or very long periods of creep, recovery, or stress relaxation from measurements made at a series of temperatures.

Production and Tensile Testing of Strain-Free Metal Specimens. G. Greetham and A. J. Martin. *J. Sci. Instr.*, May, 1960, pp. 160–162. Discussion of an electrolytic etching machine whereby single crystal test specimens of beryllium may be prepared without mechanical deformation. A modified Polanyi apparatus, in which specimens may be tested in tension at temperatures up to about 600°C., is also studied.

Elevated Temperature Testing of Flight Vehicle Materials. A. V. Levy and E. C. Bernett. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 104T*. 16 pp. USAF-supported study of the effects of elevated temperature and rapid loading on the tension, compression, and creep properties of several of the alloys used in present and future vehicle designs.

Mathematics

Normirovannaia ε-Entropiia Mnozhestv i Peredacha Informatsii Neprery nykh Istochnikov Cherez Nepreryvnye Kanaly Sviazi. M. Rozenblatt-Rot. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 265–268. 12 refs. In Russian. Analysis covering the normed ε-entropy of sets and transmission of information from continuous sources through continuous communication channels.

O Edinstvennosti Resheniia Zadachi Koshi dlia Uravneniia Parabolicheskogo Tipa. Li De-Iuan'. *AN SSSR Dokl.*, Dec. 11, 1959, pp. 979–982. In Russian. Determination of the uniqueness of solution of the Cauchy problem for an equation of the parabolic type.

Differential Equations

Spectral Theory for Linear Systems of Differential Equations. Fred Brauer. *Pacific J. Math.*, Spring, 1960, pp. 17–34. Extension to first order systems of the theory of boundary value problems and eigenvalue expansions on an infinite interval for a single differential equation of arbitrary order.

O Primenenii Metoda Malogo Parametra k Sistemam Differentsial'nykh Uravnenii s Razryvnymi Pravymi Chastiami. Iu. I. Neimark and L.P. Shil'nikov. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 51–59. 17 refs. In Russian. Application of the small-parameter method to the solution of systems of differential equations with discontinuous right-hand sides.

On the Stability of the Solutions of a System of Homogeneous Linear Differential Equations with Periodic (and Other) Coefficients. N. P. Erugin. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 818–825.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1174–1184. 12 refs. Translation.

Von Neumann Difference Approximation to Hyperbolic Equations. Milton Lees. *Pacific J. Math.*, Spring, 1960, pp. 213–222. Presentation of stability theorems for a difference analog of a hyperbolic differential equation, obtained as an extension of the von Neumann difference equation for the numerical solution of the wave equation.

Functions & Operators

On the Choice of Suitable Functions for Solving Nonlinear Equations by Iterative Procedures. J. Guest. *Australia, ARL S&M Note 262*, Nov., 1959. 7 pp.

Matrices

Determinación de Vectores y Valores Propios de una Matriz. Antonio Castell Be. *Ing. Aero. & Astron.*, Nov.-Dec., 1959, pp. 15–21. In Spanish. Analysis covering the determination of eigenvectors and eigenvalues of a matrix.

Numerical Analysis

Statistical Mechanics and the Boltzmann Equation. R. M. Lewis. *NYU Inst. Math. Sci. Div. Electromagn. Res., Res. Rep. HT-4 (AFOSR TN 60-10)*, Jan., 1960. 8 pp.

Error Bounds for an Approximate Solution to the Volterra Integral Equation. John Hilzman. *Pacific J. Math.*, Spring, 1960, pp. 203–207. Presentation of an approach to the problem using Michal's results.

Existence Theorems for Certain Classes of Two-Point Boundary Problems by Variational Methods. R. J. Driscoll. *Pacific J. Math.*, Spring, 1960, pp. 91–115. USAF-supported presentation of existence theorems for solutions of two classes of vector differential systems, one of which is a generalization of a scalar system, including a special case of the Fermi-Thomas equation. In each case, the existence theorem is established by variational methods.

Ob Ustoichivosti Periodicheskikh Dvizhenii. I. V. M. Starzhinskii. *Iași Politeh. Inst. Bul.*, Fasc. 3–4, 1958, pp. 19–68. In Russian. Evaluation of methods for determining the stability of solutions for systems of linear differential equations with periodic coefficients. The problem is related to that of stability of periodic motions in the case when coefficients in the equations of turbulent motion are represented by periodic functions of time.

Harmonická Analýza se Statistickými Testy Významnosti Jednotlivých Členu Rozvoje. Oldřich Kropáč. *Zpravodaj VZLÚ*, No. 2, 1959, pp. 16–22. In Czech. Presentation of a simple method of harmonic analysis, based on the analysis of variance. The theoretical deductions are presented and the practical value of this method is verified by means of numerical examples.

O Primenimosti Metoda Fur'e k Resheniiu Pervoi Kraevoi Zadachi dlia Kvazilineinogo Parabolicheskogo Uravneniia. A. Chifligu, V. N. Maslennikova, and L. I. Kampynin. *AN SSSR Dokl.*, Feb. 1, 1960, pp. 738–745. In Russian. Analysis of the applicability of the Fourier method to the solution of the first boundary problem for a quasilinear parabolic equation.

Physical Applications

Éléments des Calculs d'Interpolation. Donatien Cot. *France, Min. de l'Air BST 123*, 1959. 140 pp. 26 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 4,435. In French. Analysis covering the elements of interpolation calculus, reviewing the formulas of Lagrange, Newton, Gauss, and Stirling for application to functions of one variable. The problem of functions with several variables is also considered.

The Numerical Solution of Hyperbolic Systems of Partial Differential Equations in Three Independent Variables. D. S. Butler. *Royal Soc. (London) Proc., Ser. A*, Apr. 5, 1960, pp. 232–252. Presentation of a step-by-step method of solution and application to the systems of equations governing unsteady plane motion and steady supersonic flow of an inviscid, nonconducting fluid. As an example of the use of the method, the flow over a particular delta-shaped body is computed.

Numerical Methods for Calculating the Zero-Lift Wave-Drag and the Lift-Dependent Wave-Drag of Slender Wings. J. Weber. *Gt. Brit. RAE Rep. Aero. 2629*, Dec., 1959. 34 pp. Presentation of methods for solving a double integral used in the calculation of the wave drag.

Periodicheskie Dvizheniia Viazkoi Neszhimaemoi Zhidkosti. V. I. Iudovich. *AN SSSR Dokl.*, Feb. 21, 1960, pp. 1214–1217. In Russian. Presentation of a mathematical approach to the study of periodic motion of a viscous incompressible fluid.

Ogranichennost' Variatsii Nepreryvnykh Reshenii Sistemy Uravnenii Gidrodinamiki. A. M.

Molchanov. *AN SSSR Dokl.*, Dec. 21, 1959, pp. 1257–1260. In Russian. Determination of the boundedness of variation in continuous solutions for systems of equations of hydrodynamics.

O Stabilizatsii Resheniia Uravneniia Teploprovodnosti. V. M. Poliakova. *AN SSSR Dokl.*, Dec. 21, 1959, pp. 1230–1233. In Russian. Analysis covering the stability of solution for the equation of heat transfer in the case of variable coefficients.

Ob Asimptoticheskom Povedenii Reshenii Odnoi Zadachi o Teploobmene. M. M. Nazarchuk and N. I. Pol'skii. *AN SSSR Dokl.*, Dec. 1, 1959, pp. 759–761. In Russian. Analysis of the asymptotic behavior of solutions for a problem of heat transfer. The simplifying assumptions introduced into the calculation are stated.

Certain Properties of Special Operators Used in the Theory of Creep. M. I. Rozovskii. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 978–980.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1398–1402. Translation.

Nekotorye Tochnye Resheniia Uravnenii Sovmestnosti dlia Komponent Tenzora Deformatsii pri Prostom Nagruzhenii. V. D. Bondar'. *AN SSSR Dokl.*, Feb. 21, 1960, pp. 1218, 1219. In Russian. Derivation of two exact solutions of compatibility equations for the components of the deformation tensor in the case of simple loading.

Topology

Ob Usloviiakh Kompaktnosti Semeistva Poverkhnostei Konechnogo Topologicheskogo Tipa. A. G. Sigalov. *AN SSSR Dokl.*, Feb. 21, 1960, pp. 1203–1205. In Russian. Definition of the compactness conditions for a family of finite topological surfaces.

Some Simple Transformation Functions for Square and Triangular Holes with Rounded Corners. W. H. Wittrick. *Aero. Quart.*, May, 1960, pp. 195–199. Derivation of transformation functions, in the form of three-term polynomials, for the conformal mapping of the region outside a square or an equilateral triangle, having rounded corners with varying and controllable degrees of curvature, on to the region outside the unit circle

Ob Usloviiakh Razreshimosti Kraevykh Zadach Rimana i Gil'berta na Rimanovykh Poverkhnostiakh. Iu. L. Rodin. *AN SSSR Dokl.*, Dec. 31, 1959, pp. 1234–1237. In Russian. Determination of conditions for the solvability of Riemann and Hilbert boundary problems on Riemann surfaces.

O Polnoi Nepreryvnosti Matrichnykh Operatorov v Vektornykh Prostranstvakh. Iu. I. Gribanov. *AN SSSR Dokl.*, Dec. 11, 1959, pp. 975–978. In Russian. Study of three classes of completely continuous matrix operators in vector spaces with an infinite number of coordinates.

O Skhodimosti Metoda Naiskoreishego Spuska dlia Nelineinykh Uravnenii. M. M. Vainberg. *AN SSSR Dokl.*, Jan. 1, 1960, pp. 9–12. 11 refs. In Russian. Extension of the method of steepest descent to more general cases, showing its convergence for nonlinear equations in Banach spaces and giving error estimates for the approximate solution.

Solving 3-D Problems Made Simple by Stereographic Projection. Sidney Godet. *Space/Aeronautics*, May, 1960, pp. 59–65. Presentation of the basic constructions needed for visualizing and manipulating three-dimensional problems involving angles. Problem assignments and solutions are explained and the multiple resolution of vectors is outlined.

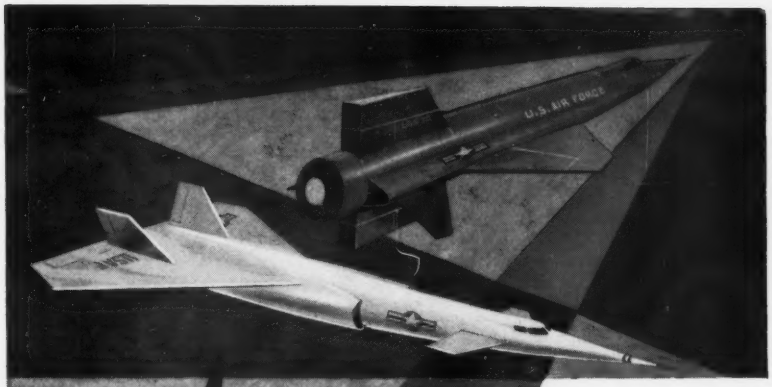
Mechanics

On the Theory of Vibrations of Elastic Bodies with Liquid Cavities. N. N. Moiseev. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 862–878.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1233–1254. Translation. Discussion covering the derivation of the general equations, the solvability of fundamental problems, an analysis of the spectrum, and a formulation of the variational principles and their derivation.

Ob Osobennostiakh Resonansnykh Kolebanii Dvukh Mekhanicheskikh Sistem. S. S. Korablev. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 137–140. In Russian. Experimental investigation of two mechanical systems, using previously obtained data to verify the results of tests on resonance vibrations.

K Grafo-Analiticheskim Metodam Issledovaniia Prostranstvennykh Mekhanizmov. D. Manzheron, Korneliu Dregan, N. Irimichuk, and Oktav Muntianu. *Iași Politeh. Inst. Bul.*, Fasc. 3–4, 1958, pp. 287–290. 17 refs. In Russian. Application of the method of vector cylindrical coordinates to derive, on the basis of previously obtained results, certain theorems for the graphical problem covering the distribution of velocities and accelerations in the three-dimensional motion of solid bodies.

Ob Ekvivalentnosti Kriteriia Ustoichivosti po Rausu-Gurvitsu i po Markovu. Vladislav Iarominek. *AN SSSR Dokl.*, Feb. 21, 1960, pp. 1224–1227. In Russian. Formulation of a stability criterion, analogous to the Routh-Hur-



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vitz criterion—i.e., Markov criterion, and solution of the inverse stability problem for linear systems.

Random Signals in Engineering Systems. J. H. Milsum. *Canada, NRC DME/NAE Quart. Bul. No. 1,* Jan. 1–Mar. 31, 1960, pp. 13–41. Discussion describing random signals, giving examples, and presenting analytical and computational techniques for handling systems subjected to these signals.

Meteorology

Similarities of the Meteorological Situations in Which Aircraft Were Damaged by Heavy Hail. T. N. S. Harrower and D. C. Evans. *Meteorological Mag.*, Mar., 1960, pp. 80–85. Study of the meteorological situations and of the damage suffered by aircraft, postulating the inclusion of hail in forecasts so that pilots can change their intended tracks to avoid damage to their craft.

Geostrophic and Gradient Departures in Jet Streams. R. M. Endlich and G. S. McLean. *J. Meteorology*, Apr., 1960, pp. 135–147. 21 refs. Comparison of wind measurements made by aircraft of Project Jet Stream with geostrophic and gradient winds (computed on upper-air charts) in order to determine geostrophic and gradient departures. The statistical significance and theoretical consequences of the departures are discussed.

Possible Key to the Dilemma of Meteorological "Angel" Echoes. David Atlas. (*AMS 7th Weather Radar Conf., Miami Beach, Nov. 17–20, 1958.*) *J. Meteorology*, Apr., 1960, pp. 95–103. 22 refs. Review of the theory of the back-scatter from invisible atmospheric targets which are likely sources of "angel" echoes, showing that surfaces of large radius of curvature, such as planes, bubbles, or sheaths with limited roughness, can account for some of the reported angel cross sections with large but not unreasonable reflection coefficients and refractive index gradients.

Numerical Prognosis Including Non-Adiabatic Warming. G. J. Haltiner and Yeh-chun Wang. *J. Meteorology*, Apr., 1960, pp. 207–213. Presentation of an improved model for the numerical prediction of the 1,000 mb. surface, which includes a term expressing the interchange of sensible heat between the air and the underlying surface, as well as the effect of terrain-induced vertical motion.

A Prediction and Decision Method for Applied Meteorology and Climatology, Based Partly on the Theory of Games. T. A. Gleeson. *J. Meteorology*, Apr., 1960, pp. 116–121. 12 refs. USAF-sponsored research.

Controllo delle Previsioni Meteorologiche. Saverio la Gioia. *Riv. Meteorologia Aero.*, Jan.-Mar., 1960, pp. 33–51. In Italian. Discussion of the importance of weather forecast control and description of a method illustrated on several examples.

Atmospheric Structure & Physics

Stability of an Idealized Atmosphere. I—Discussion of Results. K. M. Case. **II—Zeros of the Confluent Hypergeometric Function.** F. J. Dyson. *Phys. Fluids*, Mar.-Apr., 1960, pp. 149–157. 11 refs. Study of the stability of an idealized atmosphere with constant shear flow and an exponentially decreasing density.

The Atmosphere in Motion. R. R. Long. *Science*, Apr. 29, 1960, pp. 1287–1292. 13 refs. Survey of the research on simplified geophysical fluid mechanics, including a study of the effect of density variation and rotation on air motion.

Geostrophic Vortex Motion. Appendix I—**Ordering Approximation Procedure.** Appendix II—**Derivation of the Equations of Motion of Geostrophic Point Vortices.** Appendix III—**Geostrophic Conservation Equations for a Two-Layer Atmosphere.** G. K. Morikawa. *J. Meteorology*, Apr., 1960, pp. 148–158. 26 refs. Study of the concept of a geostrophic point vortex resulting from the incorporation of the geostrophic approximation in the equations of motion of the one-layer homogeneous atmosphere with a free surface. A consistent, systematic approximation procedure is used, yielding higher-order approximations without requiring additional physical assumptions. Application to the prediction of hurricane tracking and upper-air cyclogenesis is discussed.

Reduction of Diurnal Variation in the Reported Temperatures and Heights of Stratospheric Constant-Pressure Surfaces. Sidney Teweles and F. G. Finger. *J. Meteorology*, Apr., 1960, pp. 177–194. 23 refs. Investigation of diurnal changes computed from successive radiosonde observations taken in daylight and darkness, and of the variation of these changes with the solar elevation angle. An attempt is made to evaluate the spurious portion of these changes for principal types of instruments used by weather agencies in the United States during the International Geophysical Year.

Relationships Between Ozone and Meteorological Parameters in the Lower Stratosphere. George Ohring and H. S. Muench. *J. Meteorology*, Apr., 1960, pp. 195–206. 11 refs.

Power Spectra of Temperature, Humidity and Refractive Index from Aircraft and Tethered Balloon Measurements. E. E. Gossard. *IRE Trans., AP Ser.*, Mar., 1960, pp. 186–201. 24 refs.

A Method of Representing the Horizontal Pressure Force Without Reduction of Station Pressures to Sea Level. W. E. Sangster. *J. Meteorology*, Apr., 1960, pp. 166–176. USAF-sponsored study.

Transfer of Momentum Vorticity and the Maintenance of Zonal Circulation in the Atmosphere. S.-K. Kao. *J. Meteorology*, Apr., 1960, pp. 122–129. 15 refs. Investigation of the properties of the volume integral of momentum vorticity. The results are applied to the study of the maintenance of zonal circulation of a polar cap. It is shown that the rate of change of the vertical component of relative momentum vorticity is mainly due to (1) the effect of the convergence of meridional flux of angular momentum and its lateral boundary surface, (2) the frictional force at the earth's surface, and (3) the action of the mountains on the atmosphere. A model for the mean state of the atmosphere in the northern hemisphere, based on the distribution of the mean surface zonal wind, is studied.

Upper Air Research

Adaptation of the Radiosonde for Direct Measurement of Radio Refractive Index. A. H. Clinger and A. W. Straiton. *AMS Bul.*, May, 1960, pp. 250–252. Presentation of a technique for the conversion of a radiosonde for direct measurement of radio refractive index of the air using standard meteorological sensors.

Military Aviation, Ordnance

Puntualizaciones. F. H. Sainz. *Rev. Aero.*, Nov., 1959, pp. 907–912. In Spanish. Discussion of various types of missiles, classified according to their operational uses and range.

Explosively Loaded Metallic Cylinders. I, II. F. E. Allison, R. W. Watson, and J. T. Schriempf. *J. Appl. Phys.*, May, 1960, pp. 842–851. 17 refs. Army-supported theoretical and experimental investigation of the bursting properties of thin-walled metal cylinders loaded with high explosives.

Missile, Rocket, & Space Technology

Special Issue: 1960 Handbook Issue. *Aircraft & Missiles*, Mar., 1960, pp. 33–150. *Partial Contents:* **Missile Handbook**—United States Missile Projects; Missile Directory and Data; Research and Development Projects—Space Programs, Missiles, Propulsion Studies; Contractors Directory; Guidance—A Summary Report. **Powerplants**—Rocket Powerplant Characteristics; U.S. Aircraft Engines, Reciprocating Type; Gas Turbine Engines; Theoretical Performance of Rocket Propellant Combinations. **Aircraft Handbook**—U.S. and Foreign Military Aircraft; U.S. and Foreign Rotary Wing Aircraft; U.S. and Foreign Civil Aircraft.

Der Raum und der Mensch. W. M. Meyer. *Raketentech. & Raumfahrtforsch.*, Apr.-June, 1960, pp. 37–40, 57. In German. Extrapolation of the historical development used as basis for studying whether the mental-spiritual-physical complex "man" represents an irrefutable and invariable concept, or to that degree its development and adaptation to the requirements of the cosmic era are possible—i.e., to what extent is the space travel necessary in the further development of mankind.

Probing Interplanetary Space. S. W. Greenwood. *RAeS J.*, May, 1960, pp. 299–301. Discussion of the problems connected with the 25-day orbit around the sun.

Viaje Entre Estrellas. V. R. Altet. (*10th Internatl. Astron. Congr., London, Sept., 1959.*) *Ing. Aero. & Astron.*, Sept.-Oct., 1959, pp. 21–41. In Spanish. Presentation of a general theory for adiabatic rocket vehicles following a rectilinear trajectory in the absence of gravitational field. The mass ratio is determined for (a) conversion of momentum with respect to an earth-based observer, (b) thrust, and (c) energy balance. The particular cases of constant-thrust and photon rockets are considered, and the time paradox is examined.

Los Albores de una Nueva Ciencia: La Investigación del Espacio. J. B. Elías. *Ing. Aero. & Astron.*, Nov.-Dec., 1959, pp. 1–13. 29 refs. In Spanish. Discussion covering the exploration of space and survey of data obtained on the structure of the atmosphere, including the distribution of pressure and density in the upper layers, as well as their molecular and ion composition and temperature, van Allen radiation, along with measurements taken and techniques used.

El Ingenio X-15—Avion-Proyectil-Tripulado, para Exploración Científica en los Linderos del Espacio Atmosférico Terrestre. A. R. Ureta. *Ing. Aero. & Astron.*, Nov.-Dec., 1959, pp. 23–37. In Spanish. Historical survey of the development of X-15, including a description of the design, propulsion, operation, performance, and flight testing.

The Exploration of the Moon. Robert Jastrow. *Sci. Am.*, May, 1960, pp. 61–69. Review of the facts known about the surface of the moon, and presentation of the hypotheses accounting for them and the consequences which these would have on a lunar exploration mission. It is pointed out that the scientific importance of such an enterprise is increased by the fact that the moon, lacking an erosive atmosphere, has preserved a record of the history of the solar system.

Are the Lunik III Photos Fakes? M. E. Davies. *Astronautics*, June, 1960, pp. 46, 48, 49.

Results of Scientific Investigations Made by Soviet Sputniks and Cosmic Rockets. V. I. Krassovsky. (*ARS J.*, Jan., 1960, pp. 27–33.) *Astronautica Acta*, Fasc. 1, 1960, pp. 32–47. Survey of geophysical data acquired by Soviet satellites and lunar probes.

Le Snark SM-62 A. J. Gabrielli and D. Laurent. *Docaéro*, Nov., 1959, pp. 39–48. In French. Description of the Snark SM-62 A missile, covering its design, propulsion, guidance, and control, as well as the launching vehicle. A comparison with ballistic missiles and piloted bomber aircraft is also made.

Essais Dynamiques des Containers du "Polaris." J. Cornillon. *Docaéro*, Nov., 1959, pp. 31–38. In French. Discussion covering the type of container necessary for providing insulation from environmental effects during the ground phase of missile operation. Two prototypes for the capsule and for the equipment of the Polaris missile are described. Results of tests are presented, and the modifications based on these data are described.

The Australian Sounding Rockets Long Tom and Aeolus. D. A. H. Bird. *RAeS J.*, May, 1960, pp. 277–289. 12 refs. Survey of the design and performance characteristics of the high-altitude rockets Long Tom and Aeolus.

Can VTOL Rotor Concept be Used for Re-Entry? Ch. R. Haig, Jr. *Aircraft & Missiles*, Apr., 1960, pp. 38–40. Analysis of the possible use of a folding blade system for re-entry braking and landing maneuvers. Performance and theoretical considerations, as well as system's weight evaluations, are included.

Thermal Design for Tiros. Milton Ritter. *Astronautics*, June, 1960, pp. 40, 41, 92, 94, 96. Presentation of an analysis covering the problem of obtaining the best temperature regime with the only available significant parameters being: the surface radiative properties, the hour of launch, and the degree of thermal communication among the mass elements of the satellite. Results of tests on the complete satellite, designed to simulate orbital conditions, are also included.

Basic Structures for Air Launched Missiles. R. H. Loughran and L. A. Nelson. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 106U.* 8 pp. Survey of the requirements and characteristics of basic structures in air-launched missiles as compared to other missile types. The effect of missile structural weight on missile prelaunch weight, the effectiveness of thermal lag in reducing missile structural weight, and materials considerations are discussed.

Safety, Simplicity Stressed in Saturn Design Approach. J. S. Butz, Jr. *Av. Week & Space Tech.*, May 9, 1960, pp. 52–54, 59, 61–66 (ff.). Discussion of the design features, the start and launch sequence, and recovery of the Saturn family of boosters.

Entwicklung und Konstruktion der A4-Zelle. G. Wischhöfer. *Raketentech. & Raumfahrtforsch.*, Apr.-June, 1960, pp. 50–57. In German. Historical survey of the development of the V-2 structure and discussion of the reasons for the selection of certain characteristics. Changes in the fuselage and tank construction made during the development process are examined.

The Problem of Piercing at Cosmic Velocities. M. A. Lavrent'yev. (*Iskusstv. Sputniki Zemli*, No. 3, 1959, pp. 61–65.) *U.S., NASA TT F-40*, May, 1960, 6 pp. Translation. (Also in *ARS J. Suppl.*, Apr., 1960, pp. 386-388.)

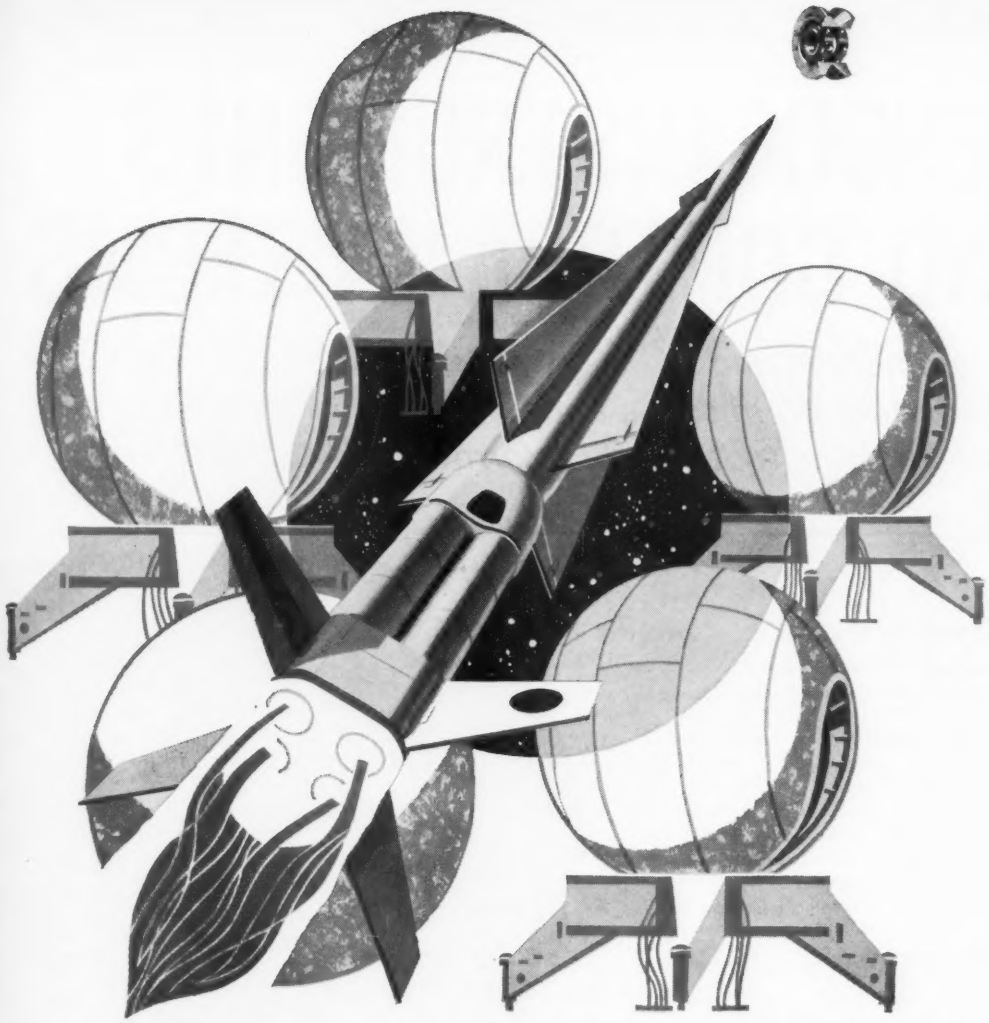
Structural Design of Tiros I. C. C. Osgood. *Astronautics*, June, 1960, pp. 42, 43, 90, 91. Discussion of the considerations and operational requirements leading to a completely strain-controlled structure employing riveted aluminum-alloy rib and sheet and special surface coats. Discussion of the design and of the results of vibration analysis are also included.

Flexible Reentry Gliders. F. M. Rogallo and J. G. Lowry. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 175C.* 6 pp. Presentation of some results of preliminary investigations of flexible gliders that are thought to have several areas of application in aeronautics and space flight, including their possible use as re-entry gliders. The glider discussed is a flexible aerodynamic surface which is essentially a tension structure of very light weight per unit of area.

Man Into Space. *Shell Av. News*, Mar., 1960, pp. 11–14. Discussion of the design, materials used, and construction of the Atlas tank.

Lightweight Suntracker for Balloon Applications. M. L. Shechet. *Rev. Sci. Instr.*, May, 1960, pp. 546–550. Discussion of the design, operation, and performance of a lightweight inexpensive suntracker. A very simple and reliable acquisition and tracking technique which uses no vacuum tubes or transistors is presented.

Key Equipment for Tiros I. E. A. Goldberg and V. D. Landon. *Astronautics*, June, 1960, pp.



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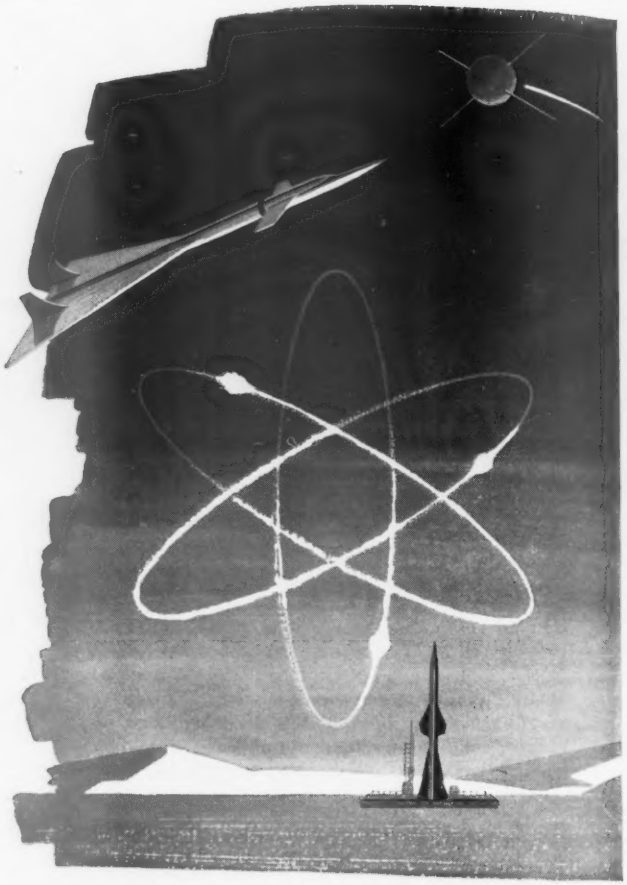

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36, 37, 98, 99. Discussion of some of the key components of the operational and control sub systems.

The Tiros I Timer. J. D. Freeman. *Astronautics*, June, 1960, pp. 35, 78, 79. Discussion of the function and design of the Tiros clock and sequence timer which provides the necessary timing controls for both of the Tiros TV cameras.

Pioneer V's UHF Link Covers 50 Million Miles of Space. P. F. Glaser and E. R. Spangler. *Space/Aeronautics*, May, 1960, pp. 162–165. Functional study of the telemetry package and system of the Pioneer V payload. Design details of the transmitters, the receiver, and the Telebit digital telemetry system are discussed. The solar-cell power supply and the temperature control of the electronics package are also reviewed.

Recording the Astronauts. *CEC Recordings*, 1st Quart., 1960, pp. 11–13. Discussion of the test program of the Project Mercury, the instrumentation, and the measurements to be taken on board of the capsule.

Technik der Bildübertragung der Mondrückseite. W. Speer. *VDI Zeitschrift*, Apr. 21, 1960, p. 456. In German. Evaluation of available data on the photographic technique used for picture transmission from the Soviet moon probe.

Izmereniia Radiatsii pri Poiete Vtoroi Kosmicheskoi Rakety. S. N. Vernov, A. E. Chudakov, P. V. Vakulov, Iu. I. Logachev, and A. G. Nikolaev. *AN SSSR Dokl.*, Jan. 21, 1960, pp. 517–520. In Russian. Brief description of instruments used in the second Soviet cosmic rocket and presentation of some results of the preliminary data processing, covering measurements taken at distances ranging from 9,000 to 120,000 km. from the center of the earth and in the near-lunar space, starting with distances of 40,000 km. from the surface of the moon.

Support Systems. I—Scope and Techniques. B. M. Teague. *Aero/Space Engrg.*, July, 1960, pp. 16–19. Discussion including definitions, provisioning procedures, and factors in the selection of the equipment.

Testing the Titan. *CEC Recordings*, 1st Quart., 1960, pp. 3–5. Discussion of the performance and of the test program of the Air Force's Titan missile.

Evaluation of Preflight Risks by Means of Very High Speed Digital System Simulation. J. R. Brinkerhoff. (*ARS Flight Testing Conf., Daytona Beach, Mar. 23–25, 1959.*) *ARS J.*, May, 1960, pp. 493–495. Description of the mathematical and programing techniques employed in using a digital computer simulation of a complex system to provide accurate data on the chance of a successful operation of the system in a specific test.

GYTAR. Steve Erenburg. *Kearfott Tech. News Bul.*, Mar.-Apr., 1960, pp. 3–5, 18. Discussion of the design, application, and operation of the GYTAR system, which determines true north semiautomatically in all weather conditions, day or night, has a short readiness time, and is portable and simple to operate.

Procedure for Optimizing Ground Support Equipment as Applied to Falcon Missiles. B. A. McDonald. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 97V.* 9 pp.

Thor Ground Support Equipment—An Engineering Challenge. R. Stoner and F. C. Allgreen. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 97U.* 9 pp. Description of the Thor ground equipment and the sequence of the countdown.

Boot-Strap Launching—A Step Toward Simplified GSE. Ch. C. Worstell and W. A. Beck. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 163B.* 12 pp. Computer study of a method using the thrust of a missile to erect the missile from its horizontal position before release to free flight. The study to determine the degradation of missile performance from this launching technique is divided into three parts: elevating, initial flight to 5-sec. elapsed time from start of thrust, and climb and cruise. Effects of changes for release and holding structures are evaluated.

System Test GSE for Modern Weapons Systems. W. M. Alford and D. W. Cogswell. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 163A.* 14 pp. Presentation of a procedure for developing test plans for use with automatic test equipment.

How PCM Keeps Tabs on Minuteman. J. P. Kushnerick. *Aircraft & Missiles*, June, 1960, pp. 17–19. Discussion of the rapid, accurate data acquisition scheme used in test firings to verify the theoretical performance of the Minuteman ICBM.

The Tiros System on the Ground. J. E. Keigler and C. B. Oakley. *Astronautics*, June, 1960, pp. 44, 45, 100–103. Discussion of the interrelated functions of data-receiving stations, data-preparation and data-utilization agencies, the computation center, and the system-control command.

Spectrometric Analysis of Missile Flights. J. N. Day, Jr. *Electronics*, May 20, 1960, pp. 87, 88. Investigation of in-flight plume characteristics to yield data pertinent to the development of more efficient fuels and engines. These data could be also used for missile detection, advanced infrared homing systems for antimissile-missiles, development of decoy tactics, and improvement of re-entry vehicles.

Tracking Radar for Tiros Weather Satellite. H. E. O'Kelley. *Electronics*, Apr. 15, 1960, pp. 57–60. Description of the design, performance characteristics, and the principles involved in the circularly-polarized, high-gain antenna which uses an especially designed feed to lock on the Tiros meteorological satellites. The method of producing a conically scanning main beam, the prism design, data flow, and the antenna structure are studied.

Zur Wirtschaftlichkeit und Technik der Bergung grosser Raketenstufen. H. H. Koelle. (*ASME Aero. Conf., Los Angeles, Mar., 1959.*) *Raketentech. & Raumfahrtforsch.*, Oct.-Dec., 1959, pp. 105–108. In German. Discussion of the economical and technical considerations in booster recovery. Initial vehicle requirements, recovery cost, booster rotation time, and various correction factors are defined, and recovery schemes based on parachutes, wings, turbojets, and their combinations are evaluated.

Ballistics, Re-Entry

Initial Azimuths and Times for Ballistic Lunar Impact Trajectories. W. C. Riddell. *ARS J.*, May, 1960, pp. 491–493. Derivation of expressions showing approximately the launch azimuths and launch times for which a ballistic missile will hit the moon. Also shown are the conditions producing the smallest angle of intersection between the missile plane and the lunar plane, and those giving an optimum launch azimuth.

Considerations of the Rendezvous Problems for Space Vehicles. J. C. Houbolt. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 175A.* 21 pp. Study of the problem of rendezvous in space to evaluate fuel consumption levels that are associated with various corrective maneuvers, and to determine the times that are suitable for initiating the rendezvous operation.

Electrically Charged Missile in Vertical Descent. M. H. Hewitt. *ARS J.*, May, 1960, pp. 505, 506. Calculation of the Lorentz deflection of an electrically charged missile in vertical descent from low altitude and comparison with the Coriolis displacement in the northern hemisphere.

Heating Penalty Associated with Modulated Entry Into Earth's Atmosphere. J. V. Becker. *ARS J.*, May, 1960, pp. 504, 505. Analysis covering two cases: (1) where force modulation is used to permit steeper entry path angles for a specific resultant force limitation of 10g, assuming that all of the entries have the same initial velocity and the same velocity decrement in the pull-up maneuver; and (2) holding the entry angle as well as the other initial entry condition constant—i.e., utilizing modulation to reduce the resultant force rather than to permit steeper entry.

Guidance, Control, Stability

Performance and Design Criteria of an Adaptive Circuit Proposed for a Space Re-Entry Vehicle. Appendix I—**Stability Analysis for the Attitude Control Loop.** Appendix II—**Rate of Change of the Rate Loop Gain.** William Beauchemin. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 171A.* 18 pp. Analysis showing how aerodynamic and structural bending characteristics of the vehicle establish design criteria and performance requirements and affect the choice of an adaptive circuit for an automatic flight control system. The adaptive circuit described includes a linear gain-changing element which maintains the rate loop of the flight control system at its neutrally stable point.

Tiros I Spin Stabilization. Harold Perkel. *Astronautics*, June, 1960, pp. 38, 39, 106. Discussion of the considerations leading to the use of the "Yo-Yo" de-spin mechanism and of the TEAM damper to reduce initial spin, maintain desired spin, and fix the critical spin axis.

Thrust Reaction Control Systems. H. G. Starck. *Missile Des. & Devel.*, May, 1960, pp. 24, 25. Comparison of hot gas systems with compressed gas and cryogenic systems.

Alignment Trade-Offs for In-Motion Inertial Platforms. J. E. Vaeth. *Space/Aeronautics*, May, 1960, pp. 179–182, 184, 190 Presentation of a quantitative basis for evaluating trade-offs between accuracy and settling time in the alignment of an inertial platform in a moving vehicle. Results of a three-axis analog computer study are detailed to show the significance of initial conditions and vehicle motion.

Adaptive Control Considerations for Re-Entry Flight. I, II. J. W. Clark and J. H. Ahlberg. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 175B.* 23 pp. 11 refs. Description of a series of maneuvers required to land a manned space vehicle at a predesignated airfield. The objectives of the maneuvers, the types of control and stabilization systems which can be used in such external environments, and the sources of moments which disturb the orientation of the vehicle are discussed. A computer program to determine the feasibility of using mechanical methods to optimize the dynamic response of a physical system in a changing environment is also described.

Spacecraft

Man in Space Environment. E. W. Still. *The Aeroplane & Astronautics*, Apr. 29, 1960, pp. 537–539. Abridged.

Design of Mercury Capsule and Systems. M A. Faget and R. O. Piland. *Aircraft & Missiles*, Apr., 1960, pp. 26–30. Presentation of the mission sequence, design, systems, and controls of the Mercury capsule which features shingled cobalt alloy over a titanium pressure vessel and an ablation heat shield as main structural elements. The systems have manual and automatic features which introduce necessary complexity.

Kosmicheskie Laboratorii. S. Matveev. *Radio* Nov., 1959, pp. 8–11. In Russian. Brief survey of experiments made and of instrumentation used in Soviet cosmic rockets to study the pressure, density, and temperature of the atmosphere, its composition, ionization of the upper atmosphere, magnetic measurements, and cosmic rays, as well as radiotelemetering systems for data transmission.

Besprimernyi Nauchnyi Podvig. *Radio*, Dec., 1959, pp. 3, 4. In Russian. Brief discussion of the Soviet Lunik III moon probe, its intended use, and the information obtained.

Sonde Interplanetari "Interne." Glauco Partel. *Riv. Aero.*, Dec., 1959, pp. 2209–2219. In Italian. Discussion of the feasibility of space probes to planets in the solar system and the sun itself. The escape and orbital velocity, environmental effects, guidance, and other related factors are considered.

Orbitnik I. *Riv. Aero.*, Nov., 1959, pp. 1973–1984. In Italian. Survey of available data on the Soviet Lunik III moon rocket, its objectives, and the information obtained.

Vokrug Luny. B. Danilin. *Kryl'ia Rodiny*, Nov., 1959, pp. 3, 4. In Russian. Brief discussion of the scientific progress in space exploration from the first artificial earth satellite to the space station.

Issledovanie Luny Raketnymi Apparatami. G. V. Petrovich. *AN SSSR Vestnik*, Nov., 1959, pp. 3–22. In Russian. Discussion of the Soviet moon exploration program with details of the objectives, launching procedures, instrumentation used, and results obtained. Included are tables providing data on the artificial earth satellites Sputniks I, II, and III, and on cosmic rockets Luniks I, II, and III.

The Orbits of Cosmic Rockets Towards the Moon. L. I. Sedov. (*ARS J.*, Jan., 1960, pp. 14–21.) *Astronautica Acta*, Fasc. 1, 1960, pp. 16–31.

Solar-Lunar Perturbations of the Orbit of an Earth Satellite. M. M. Moe. *ARS J.*, May, 1960, pp. 485–487. Analysis treating the perturbations of the perigee distance of 1959 delta (Explorer VI) using some simplifying assumptions. It is assumed that the angular velocity of the disturbing body (sun or moon) is small enough compared to the angular velocity of the satellite so that the disturbing body may be considered as fixed during one revolution of the satellite. This simplification makes possible the integration of the instantaneous rate of change of the orbital elements over one revolution of the satellite to obtain the change in orbital elements per revolution. The magnitude of the error made by holding the disturbing body fixed is estimated. This leads to an evaluation of the effect of the motion of the disturbing body on the semimajor axis (hence energy) of the satellite orbit.

Finding the Oblateness Effects on Satellite Orbits. Engelbert Kirchner. *Space/Aeronautics*, May, 1960, pp. 137, 138, 140, 142, 144. Presentation of a new method for determining the effects of the earth's oblateness on satellite orbits without applying the perturbation theory. Fifteen equations are given to show the formulation of the method. Results of the method are shown to agree satisfactorily with observed values.

The Transit Program. R. B. Kershner. *Astronautics*, June, 1960, pp. 30, 31, 104, 105. Discussion of the significance of the calculations by Guier and Weiffenbach of the orbit of Sputnik I as they relate to a satellite navigation system. The objectives and problems of the experimental Transit 1B satellite are presented.

Tiros I—Meteorological Satellite. Sidney Sternberg and W. G. Stroud. *Astronautics*, June, 1960, pp. 32–34, 84–86. Discussion of the functions and interrelations of the various subsystems which affect the picture taking and transmitting function of the satellite.

Observation Satellites: Problems and Prospects. II. *Astronautics*, June, 1960, pp. 26–29, 52, 54. 12 refs. Discussion of two panoramic camera designs, camera design criteria, and film processing techniques. Selection of sensors, flight paths, and orbit parameters and their influence on the geometry of coverage are also discussed.

The Plan to Revamp World-Wide Communications. G. S. Shaw. *Aircraft & Missiles*, Mar., 1960, pp. 26–30. Discussion of a proposal for electric relay satellites involving three satellites making one orbit every 24 hours around the equa-

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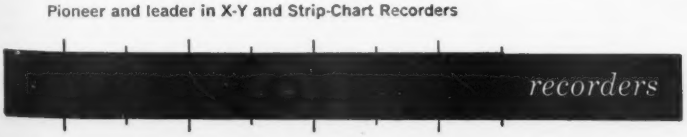

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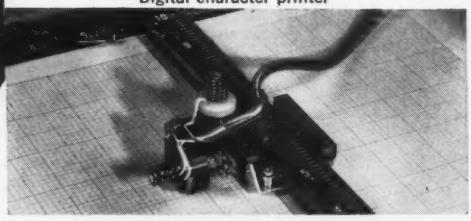

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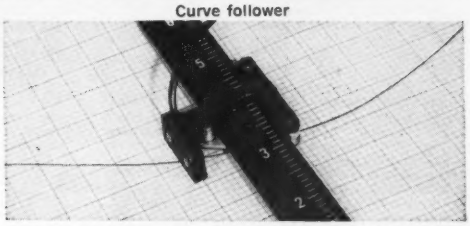

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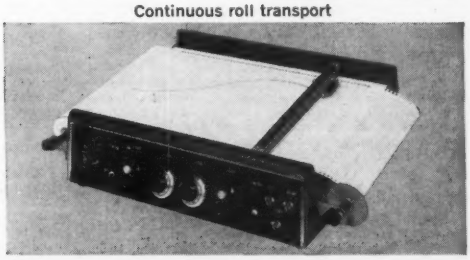

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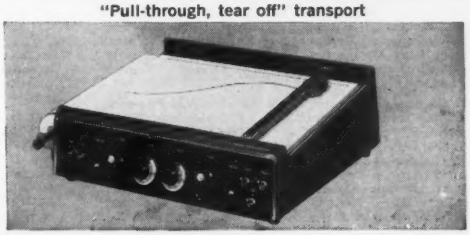

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Navigation

Radionavigation Aérienne. I. Yves Guillaume. *L'Air*, Nov., 1959, pp. 20–22. In French. Survey of various navigation systems with details of their operating principles and a tentative classification on the basis of the frequency range.

Gyrocompassing on an In-Air Moving Vehicle. Jim Stuart. *Kearfott Tech. News Bul.*, Jan.-Feb., 1960, pp. 6–8. Discussion of the requirements of the gyro compass system, its operation, and an analysis to determine the best system configuration.

A Statistical Analysis of Cross-Track Errors in a Navigation System Utilizing Intermittent Fixes. H. Staras and R. W. Klopfenstein. *IRE Trans., ANE Ser.*, Mar., 1960, pp. 15–19. USAF-sponsored presentation of a model relating navigational instrument errors to the actual cross-track error of an aircraft. An optimum procedure is developed to calibrate the compass on board the aircraft. The accuracy of arriving at a predetermined destination is evaluated. Because of the complexity of the problem, numerical calculations using the IBM 650 were made.

Designers Digest—The State of Airborne Inertial-Guidance. Donald Galbraith. *Aircraft & Missiles*, June, 1960, pp. 28–32. Discussion of the types, design considerations, and space and weight optimization in gyros. The difference between aircraft navigators and missile systems is also noted.

Electronic Aids

Elektrische Datenverarbeitung im Flugzeug. Eckhard Holscher. *Luftfahrttechnik*, Feb. 10, 1960, pp. 51–56. 16 refs. In German. Discussion of the need for electric data processing in modern high-performance aircraft; general data processing methods are illustrated.

Sistemi Elettronici per il Controllo del Traffico Aereo. Armido Pilatone. *Riv. Aero.*, Dec., 1959, pp. 2169–2181. In Italian. Description and evaluation of electronic systems designed for application to air traffic control. The basic requirements and operating principles of various ground and airborne navigation systems are considered.

Automatic Navigation for Supersonic Transports. R. F. Miller. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 111U.* 6 pp. Presentation of the implications of inertial navigation in air transportation and air traffic control.

Traffic Control

Basic Air Traffic Control System Concepts. H. K. Morgan. *IRE Trans., ANE Ser.*, Mar., 1960, pp. 12–14. Discussion of the need and the requirements for an air traffic control system for aircraft and missiles. The Bendix positive area occupancy is evaluated to show the simplicity of one possible method. Methods of expediting n a positive area occupancy system are explained.

Digital Computer to Control Air Traffic. *Aircraft & Missiles*, June, 1960, pp. 20, 21. Discussion of the performance capabilities of a data processor and of a semiautomatic data processing center which would speed routing and enhance air safety.

Zur System-Philosophie der Flugsicherungskontrolle. H. J. Zetzmann. *Luftfahrttechnik*, Dec. 15, 1959, pp. 416–424. 20 refs. In German. Analysis of the system philosophy of air traffic control, including a discussion of the necessity of coordinating military and civil services.

Nuclear Energy

Special Issue: The Engineering Design of Power Reactors. N. J. Palladino and H. L. Davis. *Nucleonics*, June, 1960, pp. 85–116. *Partial Contents*: The Conceptual Design. The Reference Design. Design Criteria and Initial Estimates. Parametric Studies. Core and Vessel Layout. Temperature Flattening. Reference Fuel Design and Development. Reactivity Requirements and Control-Rod Design. Transient Studies.

Choice of Engine Type for Nuclear Powered Multi-Purpose Aircraft. D. P. Lalor and W. C. Schmill. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 167B.* 8 pp. Study of the parametric interrelationship of the primary aircraft-propulsion system variables. It is shown that the speed for maximum productivity per megawatt does not change with engine type, that aircraft powered by turboprop engine systems are the most productive, and that increases in cruise altitude result in sharp decreases in productivity.

Nuclear Space Vehicles Using Pebble Bed Reactors. M. M. Levoy and J. J. Newgard. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 165B.* 13 pp. 14 refs. Discussion of the pebble bed reactor, its construction, and the nuclear and flow considerations, showing that pebble bed reactors are a possibility for use in nuclear space vehicles during the next ten years.

Radiation Effects Studies for the Development of Radiation-Resistant Aircraft Subsystems. J. J. Tierney. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 107T.* 24 pp. 18 refs. Discussion of the problems of operating aircraft equipment in the radiation environment of a nuclear powered aircraft. Basic considerations of radiation environment and its interaction with matter, radiation effects and the resultant damage, and studies being performed in an effort to produce radiation-resistant aircraft subsystems are presented.

Measurement of Scattered Gamma Rays by In Foil Activation. M. P. Charles. *USAF WADD TR 59-4*, Dec., 1959. 17 pp.

The Effect of Gamma Radiation on Aircraft Instrument Lubricating Oils. W. L. R. Rice. *Lubrication Eng.*, Apr., 1960, pp. 157–160. 10 refs. Evaluation of the effects of gamma radiation on three aircraft instrument lubricating oils, showing that their use in a radiation environment would be questionable. Changes in the physical and chemical properties are shown as a function of increasing gamma exposure.

The Effects of Radiation on Oxygen Designed for Human Consumption. J. F. Kircher, J. S. McNulty, J. L. McFarling, and Arthur Levy. *USAF WADC TR 59-618*, Dec., 1959. 33 pp. 24 refs. Investigation subjecting both liquid and gaseous aviator's breathing oxygen, contained under controlled pressure and temperature in stainless steel vessels, to gamma irradiation. The ozone yield appeared to be independent of pressure, but increased markedly with decreasing temperature and with increasing dose rate. In mixed field irradiations, induced radioactivity due to argon-41 was found.

Some Practical Methods for Fabricating Shields for Nuclear-Powered Aircraft. W. Q. Hullings and J. L. McDaniel. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 167C.* 11 pp. Discussion of the physical properties of borated linear polyethylene, which make it an effective, convenient, and economic neutron-shielding material. Problems and techniques involved in the fabrication of shield installations from polyethylene are discussed extensively.

Physics

The Free-Free Continuum of Oxygen. R. G. Breene, Jr., and M. C. Nardone. *G-E MSVD SSL TIS R60SD365*, Apr. 29, 1960. 11 pp. USAF-supported research.

Analytic Wave Functions. III—The Spin-Orbit, Spin-Other Orbit and Spin-Spin Interactions. R. G. Breene, Jr. *G-E MSVD SSL TIS R59SD414* (revised), Apr. 26, 1960. 16 pp. USAF-supported study.

Gazovaia Elektronika—Aktual'naia Oblast' Fiziki. N. A. Kaptsov. *AN SSSR Vestnik*, Aug., 1959, pp. 12–17. In Russian. Discussion covering the study of the process of electron and ion motion in a gaseous medium, the role of plasma physics in specific research fields, and evaluation of some methods used.

Statsionarnoe Vrashchenie Kosmicheskikh Gazovykh Mass v Obshchei Teorii Otnositel'nosti. Iu. P. Chernov. *AN SSSR Dokl.*, Dec. 1, 1959, pp. 762–765. In Russian. Determination of the steady rotation of cosmic gaseous masses in the general theory of relativity.

Cryogenics. J. H. Karlan. *Kearfott Tech. News Bul.*, Mar.-Apr., 1960, pp. 8–13, 19, 20. Review of the research done in the field of cryogenics considered within the outline of superconductivity and adiabatic demagnetization aspects.

Astrophysics

Elektronnaia Temperatura Sredy pri Sinkhrotronnom Izluchenii. G. A. Gurzadian. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 287–289. In Russian. Study covering the problem of determining the electron temperature of the medium in the presence of synchrotron radiation in stellar atmospheres.

Réactions Thermonucléaires et Chaleur Solaire. M. Jean Ville. *Soc. Ingr. Civ. France Mem.*, July-Aug., 1959, pp. 264–271. 33 refs. In French. Discussion covering the sources of solar radiation, thermonuclear processes, internal equilibrium conditions of stars, and solar models based on available data.

O Gravitatsionnoi Neustoichivosti v Ploskikh Vrashchaiushchikhsia Sistemakh s Osevoi Simmetriei. V. S. Safronov. *AN SSSR Dokl.*, Jan. 1, 1960, pp. 53–56. In Russian. Evaluation of previously established theories and discussion of the gravitational instability in plane rotating systems with axial symmetry.

Sinkhrotronnoe Izluchenie v Kometarnykh Tumannostiakh. G. A. Gurzadian. *AN SSSR Dokl.*, Jan. 1, 1960, pp. 47–50. In Russian. Presentation and evaluation of some results obtained on the synchrotron radiation in comet nebulae.

Nabliudenie Radioistochnika Strelets-A s Vysokoi Razreshaiushchei Sposobnost'iu. Iu. N. Pariiskii. *AN SSSR Dokl.*, Dec. 21, 1959, pp. 1261–1263. In Russian. Description of observations of Sagittarius-A made by means of a high-resolution radio telescope in order to study the source of radio waves.

Nabliudeniia Oblasti Tsentra Galaktiki na Volne λ 33,3 cm na Bol'shom Radioteleskope GAO. V. G. Malumian. *AN SSSR Dokl.*, Dec. 11, 1959, pp. 1003, 1004. In Russian. Description of observations of the central Galaxy region on the λ 33.3 cm. wavelength made by means of the large radiotelescope at the main observatory (GAO) of the Academy of Science, USSR.

Search for Artificial Stellar Sources of Infrared Radiation. F. J. Dyson. *Science*, June 3, 1960, p. 1667. Discussion of the considerations leading to the proposal that, in the investigations of the possibility of intelligent extraterrestrial life, a search for sources of infrared radiation should accompany the recently initiated search for interstellar radio communications.

Density of the Lunar Atmosphere. J. C. Brandt. *Science*, May 27, 1960, p. 1606. 10 refs. Study placing the particle density between 10^3 and 10^6 per cu.cm., and the electron density between 10^2 and 10^4 per cu.cm.

Pervye Rezul'taty Fotografirovaniia Nevidimoi s Zemli Storony Luny. N. P. Barabashov and Iu. N. Lipskii. *AN SSSR Dokl.*, Dec. 11, 1959, pp. 1000–1002. In Russian. Survey of photographic data on the hidden side of the moon obtained from the third Soviet moon rocket.

"The Astronomical Unit" and the Solar Parallax. Samuel Herrick, George Westrom, and M. W. Makemson. *U. Calif. UCLA Astrodynamical Rep. 5 (AFOSR TN 59-1044)*, Sept. 30, 1959. 25 pp. 24 refs. Discussion of both the classical astronomical determinations of the solar parallax and the possibility of new determinations based upon the recent radar contact with Venus and upon possible radar or transponder-assisted contacts with minor planets or vehicles in space.

Geophysics

Physical Conditions in Limb Flares and Active Prominences. I—The Loop Prominences of November 12 and 22, 1956. E. Tandberg-Hanssen and H. Zirin. (*Astrophys. J.*, Mar., 1959, pp. 408–413). *U. Col. HAO Sci. Rep. 17 (AFCRC TN 59-644)*, Dec., 1959. 8 pp. Reprint.

Physical Conditions in Limb Flares and Active Prominences. II—A Remarkable Limb Flare, December 18, 1956. Harold Zirin. (*Astrophys. J.*, Mar., 1959, pp. 414–423). *U. Col. HAO Sci. Rep. 18 (AFCRC TN 59-645)*, Dec., 1959. 14 pp. 11 refs. Reprint.

Physical Conditions in Limb Flares and Active Prominences. III—The Difference Between the Surge and Loop Prominences of December 19, 1956. E. Tandberg-Hanssen. (*Astrophys. J.*, July, 1959, pp 202–214.) *U. Col. HAO Sci. Rep. 19 (AFCRC TN 59-646)*, Dec., 1959. 15 pp. 12 refs. Reprint.

Classification of Solar Prominences—IX—1946. D. H. Menzel and F. S. Jones. *Harvard U. HCO Solar Dept. Sci. Rep. 5 (AFCRC TN 60-243)*, Mar., 1960. 50 pp.

Some Remarks on the Interaction of Solar Plasma and the Geomagnetic Field. J. W. Warwick. (*J. Geophys. Res.*, Apr., 1959, pp. 389–396.) *U. Col. HAO Sci. Rep. 16 (AFCRC TN 59-643)*, Dec., 1959. 8 pp. 12 refs. Reprint. Review of magnetohydrodynamic and ion-cloud theories of magnetic storms and auroras suggesting difficulties connected with the small scale of magnetic disturbances from point to point on the earth's surface. Currents flowing in ion clouds closer than one earth's radius from the surface of the earth appear to be necessary to explain the difficulties. It is concluded that such currents will flow in plasma sheets moving along the curved magnetic lines of force as a condition of dynamic balance of centripetal forces.

Experiment Luxembourg. G. C. Rumi. *U. Alaska Geophys. Inst. Sci. Rep. 3 (AFCRC TN 60-275)*, Feb., 1960. 21 pp. 23 refs. Study concerning the contribution of meteoric ionization to the formation of the upper layer in the *D* region and to the absorption of radio waves.

Prostranstvennaia Zadacha Obtekaniia Vozvyshennosti Neogranichennym Sverkhu Vozdushnym Potokom. B. N. Trubnikov. *AN SSSR Dokl.*, Dec. 1, 1959, pp. 781–784. In Russian. Study of the three-dimensional problem of circulation over elevations of arbitrary shape for an atmosphere extending upward to infinity.

Some Results of the Determination of the Structural Parameters of the Atmosphere Using the Third Soviet Artificial Earth Satellite. V. V. Mikhnevich, B. S. Danilin, A. I. Repnev, and V. A. Sokolov. (*Iskusstv. Sputniki Zemli*, No. 3, 1959, pp. 84–97.) *U.S., NASA TT F-13*, May, 1960. 19 pp. 37 refs. Translation.

Kosmicheskii Vozraat Sikhote-Alinskogo Meteorita. E. K. Gerling and L. K. Levskii. *AN SSSR Dokl.*, Jan. 1, 1960, pp. 45, 46. In Russian. Presentation of results of measurements made to determine the cosmic age of the Sikhote-Alin meteorite.

Ul'trafioletovoe Izluchenie i Vozbuzhdenie Kislorodnykh Linii v Khromosfere. G. M. Nikol'skii. *AN SSSR Dokl.*, Jan. 1, 1960, pp. 51, 52. In Russian. Study of the mechanism

of ultraviolet radiation and excitation of oxygen lines in the chromosphere.

Interferometricheskoe Izmerenie Shirin Emissii λ 6300 Å [O I] i λ 5198-5200 Å [N I] v Poliarnykh Siianiiakh. T. M. Muliarchik. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 303–306. In Russian. Description of interferometric measurements of λ 6300 Å [O I] and λ 5198–5200 Å [N I] emissions from auroras.

High-Altitude Cosmic Ray Measurements at Fort Churchill. I. B. McDiarmid and D. C. Rose. *Can. J. Phys.*, May, 1960, pp. 638–641.

Theoretical World Curves at Maximum Ion Density in a Quiet *F*-Region. J. E. C. Gliddon and P. C. Kendall. *J. Atmos. & Terrestrial Phys.*, No. 1, Apr., 1960, pp. 48–60.

Lunar Tidal Variations in the Ionospheric Layers. N. N. Rao and H. M. Swarm. *Trend in Eng.*, Apr., 1960, pp. 15–22. 15 refs. Evaluation of the effects of lunar tides upon the ionospheric parameters, and comparison of the theoretical with experimental results.

Ion-Atom Interchange. D. R. Bates and M. Nicolet. *J. Atmos. & Terrestrial Phys.*, No. 1, Apr., 1960, pp. 65–70. 19 refs. Discussion arguing that the ion-atom interchange processes of importance in the upper atmosphere are very much slower than simple collision theory has presented them. The rate coefficients involved are thought to be sensitive to the temperature.

Geomagnetic Westward Drift and Irregularities in the Earth's Rotation. M. G. Rochester. *Royal Soc. (London) Philos. Trans., Ser. A*, May 26, 1960, pp. 531–555. 25 refs. Extension of Bullard's rigid sphere model for steady westward drift of the earth's nondipole magnetic field to include the magnetic coupling provided by the presence of the higher multipole fields at the core-mantle boundary.

Optics

Investigation of Far Infrared Spectra. R. C. Lord. *USAF WADC TR 59-498*, Feb., 1960. 29 pp. 30 refs.

Attenuation of Infrared Radiation by Fogs. S. W. Kurnick, R. N. Zitter, and D. B. Williams. *OSA J.*, June, 1960, pp. 578–583. 13 refs. USAF-sponsored investigation of the optical transmission in fogs for wavelengths from 1–11 μ. The measurement results, together with the data of Arnulf, Bricard, Curé, and Véret, are analyzed under the assumption that particle sizes in natural aerosols follow the distribution law proposed by Junge.

Prism Scanner. F. A. Rosell. *OSA J.*, June, 1960, pp. 521–526. Analysis of design parameters of the prism scanner appropriate to a system's design for infrared scanning. A thin prism approximation and a more exact thick prism analysis are used in the investigation. The results are specialized to the case of the spiral mode, but the method is applicable to other modes.

Power Plants

Non-Propulsive Power for Advanced Vehicles. III. R. W. Curran. *Space/Aeronautics*, May, 1960, pp. 52–54. Discussion of open- and closed-cycle fuel-cell designs; photo-voltaic, static, and dynamic techniques of converting solar energy to electric power; and nuclear power systems. Status, optimum power ranges, duty life, advantages, and disadvantages of each design are given.

Non-Propulsive Power Systems for Missiles and Space Vehicles. D. K. Breaux and R. L. Schultz. (*CAI Mid-Season Meeting, Edmonton, Feb. 19, 1960.*) *Can. Aero. J.*, May, 1960, pp. 170–177. Discussion of the performance requirements, fundamental design concepts, and propellant selection for direct conversion devices.

The Selection of Accessory Power Systems for Long-Duration Manned Space Vehicles. E. T. Raymond. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 154A.* 26 pp. Discussion of the expected power demands predicted for long duration space ships and of the factors that affect the selection of a power system for such a vehicle, considering also the applicable power systems. Finally, the problems of integrating several solar power systems and a nuclear power system are discussed, and typical extension mechanisms studied are illustrated.

SNAP *2*—A Reactor Powered Turboelectric Generator for Space Vehicles. G. M. Anderson. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 154B.* 18 pp. Discussion of the SNAP experimental reactor, a sodium to mercury heat exchanger which was developed and tested within the SNAP 2 project, aimed at developing a space power system for use in the 1962–1963 period. A complete rotating unit is demonstrated and the state of SNAP 2 project is noted.

Arc-Jet and Photon Rockets; Propulsion for Near and Far Future. III. K. R. Stehling. *Space/Aeronautics*, May, 1960, pp. 42–45. Survey of arc-jet rocket design and of the prospects for photon propulsion. Basic principles, important design problems (including electrode design and cooling provisions), and probable applications of the arc-jet type are discussed.

Electric Propulsion and Power Requirements for Space Vehicles. F. D. Stull and V. W. Shiel. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 165C.* 12 pp. Presentation of electric propulsion fundamentals and of several types of electric thrust devices and their characteristics. Several possible missions are listed which could be applicable for electrical propulsion, and power requirements are presented in parametric form for the specific missions of low-altitude sustainer and orbit transfers.

Performance of Nuclear Rockets for Large-Payload, Earth-Satellite Boosters. E. W. Sams. (*IAS Natl. Summer Meeting, Los Angeles, June 16–19, 1959, Paper 59–94.*) *J. Aero/Space Sci.*, July, 1960, pp. 481–492, 516. Evaluation of the performance of single-stage, heat-transfer-type nuclear rockets using either dispersed-fuel-in-graphite reactors or tungsten-fuel-element-in-BeO reactors with hydrogen as a propellant.

Instrumentation for Plasma Propulsion. J. J. Pearson. *Electronics*, June 10, 1960, pp. 66–69. Navy-supported discussion of a proposed low-thrust, long-endurance plasma pinch engine, and of the instrumentation necessary to collect test data on plasma effects.

Jet & Turbine

Allison *250*—Eine wirtschaftliche Fluggasturbine kleiner Leistung. *Luftfahrttechnik*, Apr. 10, 1960, pp. 118–121. In German. Description of the Allison Mhdel 250 engine, covering the essential design criteria and the mechanical configuration.

The JT12 Pratt & Whitney Aircraft's 3000 lb. Thrust Turbojet Engine. D. G. Phinney. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 103U.* 14 pp. Discussion of the design and development of the JT12 turbojet engine. Design procedures used on the compressor, turbine and blade designs, and problems encountered in designing the bleed valve and in solving the diffuser cracking problem are presented.

Turboprop Without a Rival. *The Aeroplane & Astronautics*, Apr. 22, 1960, pp. 482–488, cutaway drawing. (Also in *Flight*, Apr. 22, 1960, pp. 563–567.) Presentation of the development history, design, and performance of the Rolls-Royce Tyne, two-spool engine.

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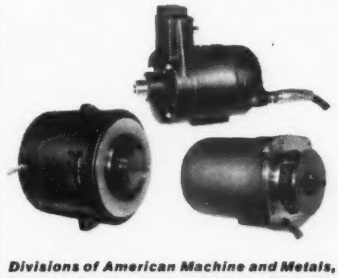

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Bristol-Siddeley-Mantelgebläsetriebwerke mit hohem Kalt-/Warmstrom-Verhältnis. G. M. Lewis. *Luftfahrttechnik*, Mar. 10, 1960, pp. 80, 81. In German. Description of the Bristol-Siddeley ducted-fan turbojet engine with a high by-pass ratio.

Das Zweistromtriebwerk. A. G. Newton. *Luftfahrttechnik*, Mar. 10, 1960, pp. 75–79. In German. Survey of the principal features of the Rolls-Royce "Convay" by-pass engine. Such aspects as specific fuel consumption, thrust deflection, efficiency, and noise are considered.

Expérience Acquise Avec la Turbine à Gaz Lycoming T53 Utilisée pour la Propulsion des Hélicoptères et des Aérodynes à Décollage et Atterrissage Verticaux. A. Franz. *Tech. & Sci. Aéronautiques*, Sept.-Oct., 1959, pp. 325–328. In French. Description of the Lycoming T53 gas turbine and of its use in the following aircraft: Bell H40, Kaman H43B, Vertol 105, and Vertol 107 helicopters; Grumman AO-1 "Mohawk" fixed wing STOL and Vertol 76 tilt-wing VTOL aircraft; and "Ryan" 92 VTOL and "Doak" 16 VTOL models.

The Turbofan Engine and Its Application Versatility. S. M. Taylor and C. B. Brame. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 172A*. 13 pp. Discussion of the features of the turbofan which allow it to match or exceed the turboprop and the turbojet throughout their performance spectrum. Comparisons of performance are made for turbojets and a turbofan, considering five different-weight, four-engine transports and a two-engine transport.

Turbofan and By-Pass Type Engines for Jet Transports. A. A. Lombard and D. Gerdan. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 172C*. 11 pp. Survey of the development of the Rolls-Royce Conway engine.

Trends in Navy Turboprop/Turboshaft Engine Developments. A. L. Rasmussen. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 170A*. 14 pp. Discussion of naval requirements for shaft-power turbine engines, and description of some of the more important aspects of turboprop and turboshaft engines under development to fill these requirements. Included in the coverage are performance, variation in configuration, applications, and developmental problems to be solved.

Aft Fan Engines for Commercial Transport. B. J. Gordon and R. C. Hawkins. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 172B*. 14 pp. Discussion of the advantages of an aft-fan engine in noise reduction and mechanical simplicity.

Current Problems in Aero Engine Design. E. S. Moult. (*13th Louis Blériot Lecture, Paris, Mar. 2, 1960.*) *RAeS J.*, May, 1960, pp. 259–272. Discussion of the trends in air transport service and of the types of engines likely to be used for future requirements. Engine problems which are associated with supersonic flight, especially the high temperature problem, are also studied.

Messeinrichtungen auf Prüfständen für Strahlturbinen. Karl Zeilinger. *Luftfahrttechnik*, Apr. 10, 1960, pp. 113–117. In German. Description of measuring equipment used to obtain the principal desired values on a turbojet test stand for mass produced power plants.

Kontrol' Lopatok Turbin Ul'trazvukom. A. Borovikov and R. Likhachev. *Grazhdanskaia Aviatsiia*, Nov., 1959, pp. 25, 26. In Russian. Discussion of the application of ultrasonic techniques to the testing of turbine blades.

Water Makes "Freedom Fighter" Hotter. Philip Geddes. *Aircraft & Missiles*, May, 1960, pp. 42–44. Discussion of precompressor cooling used in the J85-5 turbojet of the N156F lightweight fighter, thus increasing its performance to Mach 2.1. The interrelationship of airframe and speed is pointed out.

The Design and Development of the General Electric CJ805-3 Thrust Reverser and Noise Suppressor. W. S. Bertaux. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 162B*. 15 pp.

Ram-Jet & Pulse-Jet

Diesel Ramjet Design. R. A. Cole. *Aircraft & Missiles*, May, 1960, pp. 50, 51. Discussion of a new approach to ram-jet design, suitable for very high speed flight and, possibly, for use as second-stage propulsion for large rockets. The new approach is based on the principle of spontaneous ignition of fuel by shock heating. This would eliminate the necessity to slow the internal flow to subsonic values and hence, eliminate flame holders.

Nomographisches Verfahren zur Berechnung von Staustrahltriebwerken. O. Lutz, W. Buschulte, and K. Mose. *DFL Inst. Strahltriebwerke Bericht No. 113*, July, 1959. 31 pp. 10 refs. In German. Development of a nomographic procedure for the calculation of ram-jet power plants, based on a pressure-velocity graph in dimensionless form. The effect of fuel control and cross sectional variation of the thrust nozzle on the intake process can be determined for a wide range of gas dynamic variables.

Staustrahltriebwerke der Nord-Aviation—Entwicklungsarbeiten und Erprobung in Flugkörpern. E. G. Friedrichs. *Luftfahrttechnik*, Feb. 10, 1960, pp. 45–50. In German. Brief evaluation of the development of ram-jet power plants, and discussion of methods and instrumentation for testing these power plants. The testing facilities available in France, in particular those developed by Nord-Aviation, are described along with some specific applications of ram-jet engines.

Rocket

Rocket Engine with Throttle. Philip Geddes. *Aircraft & Missiles*, June, 1960, pp. 38–40. Discussion of the design of Aerojet's sled-driving, variable-thrust rocket engine.

Application of Materials to High Temperature Service in Rocket Engines. R. P. Frohmberg. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 98V*. 9 pp. Discussion of material applications in high temperature environment from the point of view of the designer, manufacturer, and the quality control engineer.

Specific Impulse Nomograph. W. L. Senn, Jr., and R. V. Repetti. *ARS J.*, May, 1960, pp. 489–491. Presentation of a graphical method which makes possible the rapid determination of specific impulse once the various parameters of a rocket propellant system are known.

Ballistic Effect of Pyrolyzed Liner in Solid Propellant Motor Firings. L. J. Gordon. *ARS J.*, May, 1960, pp. 502, 503. Analysis of the contribution made by combustion chamber liner material lost during burning of a solid propellant motor to the momentum of the exhaust, even though it adds no energy to the stream. A relationship yielding the true propellant specific impulse from the measured thrust-time integral, the propellant weight, and the weight of liner lost in a static firing is derived. A relationship between vehicle burnout velocity and these parameters is also given.

Production

Fortschritte im Flugzeugbau durch Baugruppenunterteilung in Leichtmetall-Pressteile. H. Hertel. *Luftfahrttechnik*, Dec. 15, 1959, pp. 389–399. In German. Study showing the advantage of the integrated-structure method of production achieved by subdividing the large integrated-structure assembly groups into pressings of moderate dimensions. The design of the main section of a wing, made of pressed strip material, is studied as a practical example.

Metalworking

Elektronisch gesteuertes Kopierfräsen grosser Flugzeugbauteile. *Luftfahrttechnik*, Dec. 15, 1959, pp. 413, 414. In German. Description covering the electronically controlled contour-milling of large structural aircraft components.

Konstruktion und Fertigung einer dünnwandigen Stahl-Flugkörperhülle. R. W. Schulz. *Luftfahrttechnik*, Dec. 15, 1959, pp. 411, 412. In German. Discussion of techniques used for the design and construction of thin-walled steel-sheet metal cases, with emphasis on the Atlas missile production.

Ultra Zvok kot Tehnološko Sredstvo za Obdelavo Materialov. IV. Franc Gologranc. *Strojniški Vestnik*, No. 6, pp. 172–179. 11 refs. In Slovene. Discussion of the application of ultrasonic techniques to metalworking processes.

Znachenie Adsorbtsionnykh Vzaimodeistvii i Ob'emno-Mekhanicheskikh Svoistv Smazochnykh Sloev pri Obrabotke Metallov Davleniem. V. M. Korbut, S. Ia. Veiler, and V. I. Likhtman. *AN SSSR Dokl.*, Jan. 11, 1960, pp. 307–309. In Russian. Determination of the role of adsorptive interactions and mechanical properties of lubricating films in pressure forming of metals.

Velocity Measurements of Flame-Sprayed Aluminum Oxide Particles (Phase I of a Basic Study of Particle-Impact Processes for Applying Ceramic and Cermet Coatings). D. G. Moore, W. D. Hayes, Jr., and A. W. Crigler. *USAF WADC TR 59-658, Pt. I*, Oct., 1959. 15 pp.

Reclamation by Metal Spraying. W. E. Ballard. *Brit. Welding J.*, Apr., 1960, pp. 223–230. Review of the development of metal spraying, and a discussion of the process and its application in the reclamation of shafts and flat surfaces. The properties of the sprayed coatings are considered and the results of experimental work are given.

Hot-Dimpling. II—Development of Static Machine: Operating Sequence for Production Runs. *Aircraft Prod.*, May, 1960, pp. 190–198.

Explosive Forming. F. A. Cox and E. F. Mellinger. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint T39*. 5 pp. Discussion of the state of the art and the advantages of explosive forming. Criteria used for selecting parts to be formed by this process and future areas of development are studied.

Capping Saturn's Tanks. W. A. Wilson. *Aircraft & Missiles*, May, 1960, pp. 40, 41. Presentation of two approaches used in the fabrication of the aluminum one-piece hemispherical bulkheads.

Fabrication by Explosives. Vasil Philipchuk. (*ASME Des. Eng. Conf., New York, May 23–26, 1960, Paper 60—MD-4*). *Mech. Eng.*, May, 1960, pp. 48–50. Discussion of the processes taking place in the metal under high stress-strain rates, of methods used in explosive forming, and of material properties obtained by this procedure. A study of materials which can be explosively formed and a comparison of this forming method with conventional ones are also included.

Space Age Metal. R. A. Courtman. *Hawker Siddeley Rev.*, Apr., 1960, pp. 16, 17. Presentation of the properties of beryllium and of the safety measures used in its handling at the new large-scale Armstrong Whitworth plant for the machining of this metal.

Polishing Rotor-Discs. *Aircraft Prod.*, May, 1960, pp. 162–168. Description of an automatic-cycle rotary-brush machine for producing stress-relief radii on rotor-disc blade-root slots.

Ultra-High-Tensile Steels. L. L. Arundel and R. Kitchingham. *Aircraft Prod.*, May, 1960, pp. 176–186. Study of the machining of high-tensile steel by routing, high-speed milling, and conventional milling, using carbon dioxide as a coolant. Special cutters, cutter-geometry, and comparative data on the machining of materials of lower tensile strength and the use of conventional coolants are discussed.

Applications and Limitations of Metal Removal Techniques in Aircraft and Missile Manufacturing. Michael Field. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 169A*. 16 pp. Comparative discussion of the machining properties of the aircraft and missile alloys, pointing out the limitations in machining. The state of the nonmachining methods of metal removal and their limitations are also studied.

Future Trends in Materials Removal Techniques. M. E. Merchant. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint T40*. 12 pp. 10 refs. Examination of the trends in machining and stock removal which have taken place in recent years, as used in the manufacture of aerospace vehicles, in order to define their apparent significance for the future.

Applications and Limitations of New Developments in Metals Joining Processes. P. J. Rieppel. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 160B*. 18 pp. 72 refs. Review of new processes in fusion welding, resistance welding, high-temperature brazing, solid-state bonding, and in cutting and coating.

Theory and Application of the Plasma Arc. R. M. Gage. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint T41*. 9 pp.

Electron Beam Welding. M. E. Harper and E. G. Nunn. *Brit. Welding J.*, May, 1960, pp. 331–336. Discussion of a versatile vacuum welding equipment using an electron bombardment heat source. The factors governing its design are presented, and several of the welding techniques are given to illustrate the advantages of electron beam welding over the more conventional methods.

Flexural Fatigue Strength of Butt Welds in N.P. 5/6 Type Aluminium Alloy. J. L. Wood. *Brit. Welding J.*, May, 1960, pp. 365–380. 25 refs. Investigation subjecting the as-welded plate to alternating bending stresses applied in a direction transverse to that of welding. Losses in fatigue strength are determined, method for improving the fatigue strength of the as-welded plate are studied, effects of the various mechanical treatments that might be used for correcting distortion after welding are considered, and a comparison is made with butt welded steel.

Ultrasonic Welding; Preliminary Results in the Joining of Titanium-Alloy. *Aircraft Prod.*, May, 1960, pp. 199, 200.

Development of Partially Volatile Brazing Filler Alloys for High-Temperature Application and Resistance to Oxidation. Appendix I—**Apparatus and Procedures for Determination of Remelt Temperatures.** Appendix II—**Sample Calculation of Filler Alloy Composition After Vacuum Melting.** W. M. Lehrer and Harry Schwartzbart. *USAF WADC TR 59-404*, Dec., 1959. 38 pp.

The Science of Arc Welding. II—Consumable-Electrode Welding Arc. C. E. Jackson. *Welding J. Res. Suppl.*, May, 1960, pp. 177-s–190-s. 32 refs. Discussion of the basic concepts of volt-ampere relationship, distribution of field intensities and temperatures, metal transfer, spatter, arc forces and motion, melting rate, weld area, melting ratio, and other related factors.

Sprayed Metal Coatings for Abrasion, Corrosion, and Oxidation Resistance. G. R. Bell. *Brit. Welding J.*, May, 1960, pp. 305–311. Discussion of the development of the nickel-chromium-boride-silicate hard-facing alloys, and of the production of powders which can be sprayed and then reheated to bond them to the underlaying metal. Properties required in the powder and the technique used are described.

Sprayed Metal Coatings. G. A. Curson. *Brit. Welding J.*, May, 1960, pp. 312–317. Discussion of the development of metal spraying and of the types of equipment at present in commercial use.

Nonmetalworking

First Glass Fiber Rotor Blades Tested. Michael Yaffee. *Av. Week & Space Tech.*, May 9, 1960, pp. 87, 89, 93. Discussion of all-glass fiber

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Production Engineering

Váhové Problémy v Letectví. Bohumil Purnoch. *Zpravodaj VZLÚ*, No. 2, 1959, pp. 43–46. In Czech. Discussion of the effect of weight penalties on the efficiency of an aircraft. Methods of weight reduction and structural efficiency increase are evaluated, and such factors as the use of plastics, printed circuits, and various bonding methods are discussed.

Rozbor Některých Vztahů Mezi Konstrukcí a Výrobou Letadel. Karel Tomáš. *Zpravodaj VZLÚ*, No. 2, 1959, pp. 11–13. In Czech. Analysis of the relationship between the design of an aircraft and the specific production methods used.

Tendencias Actuales en los Materiales de la Industria Aeronáutica. J. R. Lineros. *Rev. Aero.*, Dec., 1959, pp. 1018–1026. In Spanish. Evaluation of the present status and future trends in the field of materials used for aeronautical application, with a survey of modern requirements.

K Problematice Rozboru Časových Nákladů na Statické Zkoušky Letadlových Konstrukcí. Jan Drexler. *Zpravodaj VZLÚ*, No. 2, 1959, pp. 23–30. In Czech. Discussion of some problems in the time-cost analysis of the structural airframe test program. Statistical methods are used, and a numerical example is given to illustrate the improved procedures.

What to Expect from Ultrasonics in Testing Solid-Propellant Rocket Motors. R. E. Klient and R. D. McCown. *Aircraft & Missiles*, May, 1960, pp. 30–33. Presentation of an ultrasonic nondestructive method for the checking of finished units for bonds at case-to-liner and liner-to-propellant interfaces.

Radioisotope Techniques Used to Measure Wall Thickness of Hollow Turbine Blades and Vanes. W. J. Mayer, W. H. Lange, and W. L. Shelly. *GM Eng. J.*, Apr.-June, 1960, pp. 9–14. Presentation of a measuring technique based on the amount of radiation transmitted through the walls. Attempts to measure the airfoil thickness by conventional nondestructive methods were unsuccessful due to the size and shape of the specimens and the presence of internal supporting structures in both the blades and the vanes.

Floor Control of Assembly Quality—A Practical Approach. Mark Manning and Fred Ennerson, Jr. *Ind. Qualsty Control*, May, 1960, pp. 25, 26. Discussion of the use of control charts for defects ("c" charts) in the inspection of complex assemblies.

An Experimental Method for Evaluating Honeycomb Bond Quality. E. T. Hughes and E. Burstein. *Aircraft & Missiles*, June, 1960, pp. 42–45. Investigation of a nondestructive method using the pulsed-wave technique with surface-type waves to trace the telltale signal on a cathode-ray tube.

Tooling

Convair Production; Specially-Designed Heavy Equipment for the 880 and 600 Civil Aircraft Programme. *Aircraft Prod.*, May, 1960, pp. 169–173. Presentation of a new type of completely automatic riveting machine. A spar-milling machine with electrohydraulic controls and the largest radial draw-former yet produced are also described.

Propellers

Doublet d'Hélices Coaxiales—Hélice Unique. Jean Cristescu. *France, Min. de l'Air PST 356*, 1959. 276 pp. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 8,000. In French. Presentation of several methods of calculation for paired coaxial, counterrotating propellers, as well as for single propellers. The circulation is considered (a) constant and (b) variable over the blade, (c) disappearing at the tip and hub, or (d) maximum at the hub. Mean and local induced velocities are used. For the single propeller, local induced velocities and elliptic circulation $(r/R)^2$ are used, and heavily loaded propellers are calculated. A comparison is also made with wind-tunnel results.

Reliability

Design for Reliability. B. B. Richardson. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 101U*. 9 pp. Discussion of the basic criteria in the form of "Ten Commandments for Design Reliability." The importance of simplicity of design, liberal performance margins, and greater reliability of functional equipment already in production are pointed out.

Mathematical Modes for System Reliability. II. R. E. Barlow and L. C. Hunter. *Sylvania Tech.*, Apr., 1960, pp. 55–65. Investigation of a mathematical model, proposed earlier for determining the reliability of large, complex systems. A reliability analysis is made of redundant circuits, each of whose components may fail in one of two ways. To explore the repair feature of the model in more detail, two types of preventive maintenance policies are considered.

Weapon Systems Reliability. C. E. McLaughlin. *Ind. Quality Control*, May, 1960, pp. 27–29. Discussion of some of the trends in weapon system programs and of some of the implications for reliability in these trends.

Research, Research Facilities

Selection of Methods and Instruments for Vibration and Shock Testing. T. P. Rona. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 100V*. 10 pp.

Kleinbrennkammer zur raschen Untersuchung von Kraftstoffen für Luftstrahlantriebe. G. Spengler and H. Gemperlein. *DVL Bericht No. 80*, Dec., 1959. 100 pp. Westdeutscher Verlag, Köln & Opladen. In German. Description of a test stand comprising a subsonic ram-jet engine for rapid testing of jet fuels. The results are particularly applicable to fuels used in power plants operating at a relatively low compression ratio.

Vibration Testing—Yesterday, Today and Tomorrow. C. G. Pierce. *Environmental Quart.*, Apr., 1960, pp. 18, 19. Discussion of the increased importance of temperature-vibration testing and of the basic systems which meet existing acoustic testing requirements.

Supersonic Mission Simulator. Max Gerson and Eli Zuckerman. *Instrumentation*, Jan.-Feb., 1960, pp. 18–23. Study of a new test center where components of the B-58 "Hustler" supersonic bomber are tested under conditions simulating altitudes up to 100,000 ft. and temperatures between −100° and +400°F.

Methods of Estimation in Vibration and Shock Problems. C. T. Molloy. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 100W*. 12 pp. Presentation of methods for the estimation of vibration and shock data often required in the design stages before actual measurement is possible.

Considerations in the Design of Shock and Vibration Tests. Irwin Vigness. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 100X*. 15 pp. Discussion showing that the establishment of test requirements on the basis of the maximum intensities of shock and vibration to which the equipment may be subjected is overconservative for equipment that is not negligibly light compared with the foundation on which it is mounted. A more realistic and economical test is described.

Real-Time Analysis, New Approach in Flight Testing. Guenther Hintze. (*ARS Flight Testing Conf., Daytona Beach, Mar. 23–25, 1959.*) *ARS J.*, May, 1960, pp. 500–502. Discussion of the possibility of increasing the information contents of flight records through controlled exercise of missiles during firing tests. The discussion is based on experiment to determine aerodynamic coefficients under controlled and trimmed flight conditions.

Measuring Weight and Thrust. J. W. Krebs. *Instrumentation*, Jan.-Feb., 1960, pp. 24–27. Discussion of the facility at Edwards Air Force Base for measuring weight and thrust of aircraft ranging in size from small helicopters to the largest aircraft.

Electric Arc-Powered Air Jets for Materials and Structures Testing at Temperatures to 10,000°R. R. R. Heldenfels and J. N. Kotanchik. *IAS Natl. Summer Meeting, Los Angeles, July 8–11, 1958, Paper*. 26 pp. 10 refs. Description of 700 kw. and 2,000 kw. units which produce supersonic jets of $\frac{1}{2}$ in. and $\frac{3}{4}$ in. diam., respectively, and a temperature of about 10,000°R. Some results of typical material ablation tests are presented.

A Stroboflash Pulse Sequence Generator for the Study of Turbulent Flow in Fluids. R. E. King. *Electronic Eng.*, May, 1960, pp. 294, 295. Discussion of a device in which the output of the sequence generator triggers a stroboflash which provides a photographic indication of the directions and local velocities of turbulence in a fluid.

Flight Testing

Flight Testing at Bristol Siddeley. *Bristol Siddeley J.*, 2nd Quart., 1960, pp. 67–71. Discussion of the flight development program of Bristol Siddeley. The organization, duties, instrumentation used, and types of aircraft tested are described.

Wind Tunnels

Construction et Étalonnage d'une Souffierie à Gaz Très Raréfié. F. M. Devienne, G. M. Forestier, and A. F. Roustan. *France, Min. de l'Air PST 354*, 1959. 31 pp. 23 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 570. In French. Discussion of the construction and calibration of a wind tunnel with highly rarefied gas whose static pressure in the test section can be varied during operation between 1/10 micron and several microns of mercury.

Neuzeitlicher Windkanalbau. Karl Meyer. *Luftfahrttechnik*, Apr. 10, 1960, pp. 105–112. In German. Survey of wind tunnels built in Germany prior to World War II, and description of modern transonic and supersonic tunnels. Aspects related to the design of drive and cross-sectional area of the test section are examined.

A Semi-Automatic McLeod Gauge. H. R. Pass. *USCEC Rep. 56-211 (AFOSR TN 60-399)*, Mar. 31, 1960. 36 pp. Description of a manometer for use in a low-density wind tunnel which is remotely controlled and remotely read.

Experimental Determination of Thermocouple Time Constants with Use of a Variable Turbulence, Variable Density Wind Tunnel, and the Analytic Evaluation of Conduction, Radiation, and Other Secondary Effects. A. F. Wormser. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 158D*. 25 pp. 11 refs.

Some Applications of Shock Tubes in Physicochemical and Aerophysical Research: A Survey. Theodore Baurer. *Grumman Aircraft Eng. Corp. Res. Dept. Res. Rep. RE-136*, Jan., 1960. 55 pp. 347 refs. Description of some improvements in shock-tube design and instrumentation, and presentation of the treatment of the exploding-wire phenomenon and its applications in shock-tube work.

Rotating Wing Aircraft, Helicopters

Vor der Wahl neuer Hubschrauber. I—Fortschritte im Hubschrauberbau. F. L. von Doblhoff. **II—Autopilot und Hubschrauber,** Sergei Sikorsky. **III—Vergleich zwischen Kolbenmotor und Gasturbine im Hubschrauber,** D. L. Williams. *Flugwelt*, Jan., 1960, pp. 14–21. In German. Historical survey of helicopter development, including a comparison of piston and turbine driven types, and presentation of summarized performance data.

Quelques Aspects de la Conception et de la Mise au Point des Hélicoptères (En se Référant Principalement au Bristol 192). A. Mc. Clements. *Tech. & Sci. Aéronautiques*, Sept.-Oct., 1959, pp. 273–283. In French. Description of the development of helicopters based on data obtained with the Bristol 192 model.

Sélection des Paramètres Aérodynamiques pour l'Étude des Hélicoptères. Alexis Sikorsky. (*4th Internatl. Aero. Congr. on Rotary Wings & Vertical Flight, Paris, June 15–19, 1959.*) *Tech. & Sci. Aéronautiques*, Sept.-Oct., 1959, pp. 258–272. 61 refs. In French. Discussion of the selection of aerodynamic parameters for the study of helicopters. The survey covers: (a) history of helicopter development; (b) aerodynamic considerations for hovering and vertical flight; (c) aerodynamic considerations for forward translational flight; and (d) general considerations covering stall and compressibility effects, as well as the role of weight, dimensions, and economics.

Éléments en Vue de la Présentation d'un Exposé Verbal sur l'Évolution de l'Hélicoptère-Grue MacDonnell, Modèle 120. L. R. Novak. *Tech. & Sci. Aéronautiques*, Sept.-Oct., 1959, pp. 285–294. In French. Discussion of the design and flight tests performed on the MacDonnell model 120 helicopter crane.

Speed, Low Vibration Mark Brantly B-2. Robert Stanfield. *Av. Week & Space Tech.*, May 16, 1960, pp. 111, 113, 115, 117–123 (ff.). Survey of the design, performance, and handling characteristics of a light, two-place helicopter.

Commercial Helicopters—When? J. W. R Taylor. *Flight*, May 27, 1960, pp. 719–723. Discussion of the future prospects for commercial helicopters.

A Plan to Increase Helicopter Range Sixfold. Ch. B. Fay. *Aircraft & Missiles*, Apr., 1960, pp. 42, 43. Presentation of the "floating-wing fuel tank" scheme which promises to increase the normal helicopter range of less than 400 miles to 2,100 miles, thus giving it world mobility.

Helicopter Powerplants. *Flight*, May 27, 1960, p. 724. Brief survey emphasizing the turbine power plants in development and in production.

Safety

The Pattern of Accident Control. A. H. Hall. *Canada, NRC DME/NAE Quart. Bul. No. 1*, Jan. 1–Mar. 31, 1960, pp. 1–12. Discussion of the structure of accidents in terms of environmental processes, decision processes, processes of arrest, and processes of accident investigation.

Structures

Applications of Current Materials to Hot Airframe Design. M. B. Dunn, M. D. Muskrove, and O. T. Ritchie. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 104U*. 27 pp. Discussion emphasizing designs which do not employ artificial cooling systems, but do exploit radiant cooling and the advantageous thermal characteristics of materials.

Bars & Rods

Kruchenie Tonkostennykh Sterzhnei Otkrytogo Profilia v Usloviiakh Neustanovivsheisia Polzuchesti. N. Kh. Arutiunian and M. M. Manukian. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 82–92. In Russian. Study covering the problem of thin-

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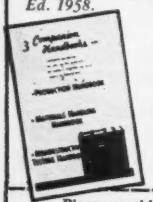

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Beams & Columns

Einfluss der Lage des Lastangriffspunktes auf die Kippstabilität eines gabelgelagerten einfachen Balkens mit doppelt- oder einfachsymmetrischem Querschnitt, der durch eine Einzelkraft in Balkenmitte belastet ist. G. Levin. *DFL Inst. Flugzeugbau Bericht No. 102,* 1959. 50 pp. 11 refs. In German. Investigation of the stability of a fork-supported simple beam with double or single symmetrical section loaded by a single force in the middle of the beam. An approximation formula is derived for the critical pitching moment, including the case of loading above or below the support.

Buckling of Unstiffened Shear Webs with Flanged Lightening Holes. M. E. Michael. *RAeS J.*, May, 1960, pp. 298, 299. Presentation of a semiempirical formula for estimating buckling and failing stresses that appears to fit the test results reasonably well for the initial buckling case.

Cylinders & Shells

On Axisymmetrical Buckling of Clamped, Shallow, Spherical Shells. Bernard Bydiansky and Hubertus Weinitschke. *J. Aero/Space Sci.*, July, 1960, pp. 545, 546. 10 refs. Navy-supported comparison of two different approaches to the analyses of the axisymmetrical buckling problem which show excellent agreement with each other but serious deviation from experimental results. It is suggested that for values of the geometrical shell parameter $\lambda > 5.5$, an analysis assuming unsymmetrical buckling is needed.

Strain-Energy Expressions in Nonlinear Shell Analysis. D. O. Brush. *J. Aero/Space Sci.*, July, 1960, pp. 555, 556. 12 refs. Analysis showing that the omission of certain bending strain-energy terms from the bending part of Langhaar's equations for thin elastic shells, leads to a wide variety of large-deflection and infinitesimal-buckling analyses.

A Statistical Method in the Theory of Stability of Shells. I. I. Vorovich. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 885–892.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1263–1272. Translation. Presentation of an approximate approach to the construction of a statistical theory of stability of shells. The practical advantages of the given method of statistical analysis are emphasized.

Uravnenie Meisnera v Sluchae Obratno-Simmetrichnoi Nagruzki. K. F. Chernykh. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 68–75. In Russian. Calculation of the inversely symmetrical loading (wind) on a shell of revolution having variable thickness, reduced to the solution of a complex, second-order equation analogous to that of Meissner.

Elasticity & Plasticity

On a Certain Conception of Dynamic Non-Steady Solution for an Orthotropic Elastic and Anelastic Semi-Space. Sylwester Kaliski. *Vibration Prob. Proc.*, No. 2, 1959, pp. 43–58. Presentation of a method for an accurate solution of the first and second boundary value problem for orthotropic elastic and anelastic bodies.

Some Relations Between the Solutions of the Plane and Axially Symmetric Elasticity Problems for the Infinite Plate. A. Ya. Aleksandrov. (*AN SSSR Dokl.*, Sept. 1, 1959, pp. 57–60.) *Sov. Phys. - Dokl.*, Mar.-Apr., 1960, pp. 1121–1124. Translation.

The Propagation of Waves in Infinite Plates. M. V. Dubinkin. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 984–987.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1409–1413. Translation. Study of the effect of annular pressure on an infinite plate considering rotary inertia and shear deformation.

A Comparison of Experimental and Theoretical Relations Between Young's Modulus and the Flexural and Longitudinal Resonance Frequencies of Uniform Bars. S. Spinner, T. W. Reichard, and W. E. Tefft. *J. Res., Sect. A - PC*, Mar.-Apr., 1960, pp. 147–155. 10 refs. Investigation using two sets of steel bars and establishing the relations from which the Young's modulus may be computed from mechanical flexural and longitudinal resonance frequencies. Empirical and theoretical results are compared.

Scattering of a Plane Transverse Wave by a Spherical Obstacle in an Elastic Medium. N. G. Einspruch, E. J. Witterholt, and Rohn Truell. *J. Appl. Phys.*, May, 1960, pp. 806–818. 15 refs. Army-supported analysis considering the scattering of a shear wave for cores in which the scatterer is the following: (a) a cavity, (b) a rigid sphere, (c) a fluid-filled cavity, and (d) an elastic material having acoustic properties different from those of the surrounding medium.

The Plane Contact Problem of the Theory of Creep. N. Kh. Arutiunian. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 901–924.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1283–1313. 17 refs. Translation. Presentation of a solution of the plane contact problem in the theory of creep, taking into account the ageing and the change of the modulus at the instantaneous deformation of the material.

Ob Uravneniiakh Linearizirovannykh Prostranstvennykh Zadach Teorii Ideal'noi Plastichnosti. D. D. Ivlev. *AN SSSR Dokl.*, Feb. 21, 1960, pp. 1232–1235. In Russian. Derivation of equations for linearized three-dimensional problems in the theory of ideal plasticity.

Zur Abhängigkeit des Elastizitätsmoduls von der Verformungsgeschwindigkeit. Werner Gohlke. *VDI Zeitschrift*, May 1, 1960, pp. 516–522. 12 refs. In German. Investigation to determine if a relationship exists between the modulus of elasticity and the rate of deformation. Two procedures are presented for the determination of the modulus of elasticity at high rates of deformation. In the case of duralumin and steel, no such relationship could be established in the speed ranges investigated.

Fatigue

The Estimation and Preservation of Turbine Powered Transport Structural Fatigue Life. J. P. Butler. *SAE Natl. Aero. Meeting, Los Angeles, Oct. 5–9, 1959, Preprint 108V.* 13 pp. 17 refs. Discussion of the preservation or maximum utilization of a given fatigue potential by the control of environmental load experiences. The Palmgren-Miner cumulative damage rule and the available statistical load data are used to estimate the time to the initiation of fatigue damage.

The Brittle Fracture Problem and the Load Carrying Capacity of Structures. L. E. Benson and S. J. Watson. *Metallurgia*, Apr., 1960, pp. 145–152. 12 refs. Discussion of the problem of brittle fracture of steel in relation to strength, showing that information on the load which a structure can safely withstand would be very much more useful than the results of conventional notch impact tests.

Plates

Wprowadzenie Siły Skupionej w Tarczę z Uwzględnieniem Warunku Równomiernej Wytrzymałości. Jacek Kapkowski. *Arch. Budowy Maszyn*, No. 1, 1960, pp. 87–97. In Polish, with summaries in English and Russian. Analysis considering the variation in thickness of a panel loaded with a concentrated force perpendicular to its edge.

Płyty Kołowe o Równomiernej Wytrzymałości Obciążone Osiowo Symetrycznie. Stanisław Łukasiewicz. *Arch. Budowy Maszyn*, No. 1, 1960, pp. 75–85. In Polish, with summaries in English and Russian. Analysis considering the problem of defining the shape of a circular plate in such a way as to have identical stress intensity at all points of the external layer. Numerical solutions are given for several forms of plates loaded axisymmetrically.

Plates with Holes

Opredelenie Napriazhennogo Sostoianiia Anizotropnoi Plastinki s Krivolineinym Otverstviem, Podkreplennym Zhestkim Kol'tsom. A. S. Kosmodamianskii. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 118–121. In Russian. Determination of the state of stress for anisotropic plates with a curvilinear hole reinforced by a rigid ring.

Rings

Elementary Stress Analysis of Circular Frames in a Cylinder Partially Filled with Fluid. A. R. Halliwell. *RAeS J.*, May, 1960, pp. 294–297. Presentation of expressions and curves for the bending moment, direct force, and shear force around a circular frame, in a cylinder partially filled with fluid. The maximum bending moment is found to occur when the cylinder is half full, and its position is found to be at the level of the fluid surface.

Sandwich Construction

Stability of Flat, Simply Supported Corrugated-Core Sandwich Plates Under Combined Loads. L. A. Harris and R. R. Auelmann. (*IAS Natl. Summer Meeting, Los Angeles, June 16–19, 1959, Paper 59-87.*) *J. Aero/Space Sci.*, July, 1960, pp. 525–534. Derivation of buckling curves by means of the Rayleigh-Ritz energy method in which the deflection surface due to shear is assumed to be of the same form as the deflection surface due to bending and twisting.

Testing Methods

Convair's B-58 Cyclic Fatigue Certification Program. C. D. Little. *SAE Natl. Aero. Meeting,*

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Los Angeles, Oct. 5–9, 1959, Preprint 108U. 9 pp. Discussion of the development of load spectra, preparation of fatigue analyses, development of test load spectra, fatigue tests of components, fatigue tests of the complete airframe, and flight data gathering programs. The relationship between these phases of the program is also studied.

Thermodynamics

Shock Hugoniots for Liquid Argon. W. Fickett and W. W. Wood. *Phys. Fluids*, Mar.-Apr., 1960, pp. 204–209. 12 refs. Calculation of shock Hugoniots for liquid argon using equations of state obtained from the Monte Carlo method and from the Lennard-Jones-Devonshire cell theory, using an experimentally determined pair potential. The Hugoniots calculated from the two methods agree well, but agreement with presently available experimental data is poor.

Combustion

The Theory of Flame Propagation. J. O. Hirschfelder and Ch. F. Curtiss. *Appl. Mech. Rev.*, Apr., 1960, pp. 231–234. 23 refs. Investigation of one-dimensional steady-state flames, showing that the flame velocity is proportional to the square root of the reaction rate, and that diffusion in simple flames decreases the flame velocity, since it has the effect of diluting the reacting gas.

Die Theorie der Verdampfung und Verbrennung des einzelnen Kraftstofftropfens. G. Rüping. *DVL Bericht No. 93*, Nov., 1959. 92 pp. 18 refs. Westdeutscher Verlag, Köln & Opladen. In German. Derivation of fundamental equations for the problem of evaporation and combustion of single fuel droplets. A survey of the literature is included, covering solutions obtained on the basis of various simplifying assumptions. The nonstationary process, the heating period, and the effect of heat radiation are also considered.

The Interaction of Weak Shock Waves with the Flame Front. G. D. Salamandra and I. K. Sevast'yanova. (*Zhurnal Tekh. Fiz.*, Nov., 1959, pp. 1360–1367.) *Sov. Phys. - Tech. Phys.*, May, 1960, pp. 1250–1257. Translation. Discussion of the influence of the distance between the ignition point and the point where the shock wave is formed, upon the composition and initial pressure of the burning mixture during the combustion of explosive mixtures in a pipe closed at both ends. The interaction of weak shock waves with the flame front and the transition from slow burning to detonation is investigated.

Izmerenie Temperatury Detonatsionnogo Fronta Vzryvchatykh Veshchestv. I. M. Voskoboinikov and A. Ia. Apin. *AN SSSR Dokl.*, Feb. 1, 1960, pp. 804–806. In Russian. Presentation of a tentative approach to the measurement of temperature in the detonation front in transparent and semitransparent charges of liquid and solid explosives, using the electron optical method.

Statsionarnaia Detonatsiia. B. V. Voitsekhovskii. *AN SSSR Dokl.*, Dec. 21, 1959, pp. 1255, 1256. In Russian. Description of equipment and methods used to study stationary detonation, and evaluation of photographic data obtained on the propagation of detonation waves.

O Raskhodiashcheisia Volne Spinovoi Detonatsii. R. I. Soloukhin. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, Nov.-Dec., 1959, pp. 145, 146. In Russian. Investigation of the structure of a cylindrically propagating detonation wave in the spin regime. Properties of acoustic waves occurring in the region behind the detonation front are also studied.

Über eine Möglichkeit, den Schub von Raketen zu vergrössern. N. St. Kalitzin and G. St. Kalitzin. *Astronautica Acta*, Fasc. 1, 1960, pp. 75–77. In German. Evaluation of possible methods for increasing the thrust of rockets. The cooling of combustion gases in the rocket chamber, achieved by injecting hydrogen into the jet, is discussed in detail.

Heat Transfer

Heat Transfer Problems of Space Vehicle Power Systems. R. A. Trusela and R. G. Clodfelter. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 154C.* 15 pp. 18 refs. Discussion of the general areas of heat transfer problems anticipated for advanced flight vehicle energy conversion systems: working fluids, emissivity, boiling heat transfer, and condensing. Research programs currently being conducted toward the solution of these problems are described.

Propagation of Thermal Waves from the Boundary of Two Media. E. I. Andriankin (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1959, pp. 991, 992.) *PMM—Appl. Math. & Mech.*, No. 5, 1959, pp. 1420–1423. Translation. Discussion of the problem of the propagation of heat from a plane boundary, and of the decay of the discontinuity of temperature, taking into account the change in phase of the material. An evaluation is carried out of the energy propagated into a medium with small thermal conductivity upon instantaneous evolution of heat at a point on the boundary seperating two media.

On Flows with Large Heat Conductions. M. N. Kogan. (*AN SSSR Dokl.*, Sept. 21, 1959, pp. 488–490.) *Sov. Phys. - Dokl.*, Mar.-Apr., 1960, pp. 974–976. Translation. Investigation of characteristic flows which take place in a gas of high thermal conductivity. The viscous flow and the heat transfer to the wall are determined for the thermal boundary layer, and the flow with very large heat conductivity is then analyzed.

Obobshchenie Resheniia Gretsa na Sluchai Luchistogo Teploobmena. E. A. Sidorov. *AN SSSR Otd. Tekh. Nauk Izv. Energ. i Avtom.*, Nov.-Dec., 1959, pp. 183–185. In Russian. Generalization of Gretz's solution for convective heat transfer in laminar fluids to cover the case of radiative heat transfer.

Radiation Cooling of Finite Heat-Conducting Solids. P. J. Schneider. *J. Aero/Space Sci.*, July, 1960, pp. 546–549. Application of Goodman's method of integrating the constant-property, heat conduction equation which can be readily adapted to the radiation problem for slabs of finite thickness (plates) and of finite internal conductance.

Perekhodnye Rezhimy Raboty Nepreryvno Deistvuiushchikh Teploobmennikov s Tolstymi Stenkami. B. N. Deviatov. *AN SSSR Dokl.*, Jan. 1, 1960, pp. 68–71. In Russian. Extension of the solution of nonstationary problems to cover the case of a thick wall separating two moving media, using the method of Laplace transformation.

Attempts to Measure the Inductive Element Associated with the Natural Convection of Heat. R. C. L. Bosworth. *Australian J. Phys.*, Mar., 1960, pp. 84–94. Investigation of the variation in time of the temperature of a wire immersed in a fluid and heated by a constant electric current.

Thermal Transients Associated wih Natural Convection. R. C. L. Bosworth and C. M. Groden. *Australian J. Phys.*, Mar., 1960, pp. 74–83. Discussion of an electric circuit consisting of parallel elements, one associated with convection alone and one with conduction alone, which is representative of the thermal processes involved in the act of setting up a system of natural convection in a fluid. The nature of the transients associated with each circuit is derived by Heaviside analysis.

VTOL & STOL

Despegue Vertical. P. L. Orellana. *Rev. Aero.*, Oct., 1959, pp. 828–832. In Spanish. Brief survey of VTOL and STOL research done in the U.S., Great Britain, and France. Covered are the various systems used to achieve VTOL and the types of craft developed.

Trends in VTOL Aircraft Propulsion System Requirements. J. B. Nichols. *SAE Natl. Aero. Meeting, New York, Apr. 5–8, 1960, Preprint 174B.* 18 pp. Comparison of various VTOL types outlining their advantages and disadvantages with emphasis on power requirements. It is concluded that there is a need for a continuation of the downward trend in turboshaft engine weight and the development of a wider variety of sizes of available hardware energies. In addition, gear boxes should be designed with provisions for cross-shafting between engines, and propeller weights should be reduced.

An Analysis of V/STOL Vehicles on a Payload-Range Basis. J. H. Aydelotte. *SAE Natl. Aero. Meeting, New York, Apr. 4–8, 1960, Preprint 174A.* 12 pp. Comparison of performance for various lifting and propelling systems in order to assist in the determination of a configuration for a useful vehicle with combined VTOL and STOL capabilities. Configurations examined include tilt wing, tilting ducted engine, helicopter, and unloaded rotor. Results show that each has particular merit in a specialized area; however, a vehicle with the combined advantages of each type is not possible within present technology.

Helicopters vs. Tilt-Wing vs. "Fixed Wing" VTOL's. I—The Trouble with "Sophisticated" VTOL Aircraft. R. P. Alex. **II—The Case for the "Tilt-Wing" VTOL.** P. J. Dancik. **III—The Case for the "Fixed-Wing" VTOL.** N. E. Nelson. *Aircraft & Missiles*, Apr., 1960, pp. 22–24.

Come Eliminare le Piste. Licio Giorgieri. *Riv. Aero.*, Dec., 1959, pp. 2153–2166. In Italian. Discussion of possible means for reducing and eliminating runways, covering the requirements of modern airports, JATO approach, VTOL and STOL designs, and aerodynamic considerations.

Ground-Effect Machines; Classification and Basic Principles of the Six Main Categories. G. D. Boehler. (*SAE Annual Meeting, Detroit, Jan. 11–15, 1960.*) *Aircraft Eng.*, May, 1960, pp. 132–136. Analysis of the basic principles which govern the operation of air-cushion devices, and establishment of six main types from which all other possible configurations can be evolved. For each of the six configurations, a critical survey is made and some comparative features are given.

Markeffektfarkoster. Alan McLean. *Tek. Tidskrift*, Dec. 18, 1959, pp. 1313–1324. In Swedish. Review of the principles, types of construction, maneuverability, stability, and potential applications of ground effect vehicles. Such projects as the Curtiss-Wright air-car, Saunders-Roe Hovercraft, Carl Weiland's car, and Bertelson's aeromobile are covered.

Ground Cushion Vehicle "Balances" with Single Engine. V. W. Wigotsky. *Des. News*, May 23, 1960, pp. 6, 7. Discussion of the design features of the "Glide-Mobile," in which two sets of static antitorque vanes located in the rear and forward areas create opposed forces to cancel out the engine's turning moment.

What's Behind the VTOL/STOL Dilemma? *Aircraft & Missiles*, Apr., 1960, pp. 17–19. Presentation of the fan-in-wing power-plant scheme as the most versatile, trend-establishing approach. The basic methods of converting propulsive power to lift power and the "Vertifan" concept, design, and performance are discussed.

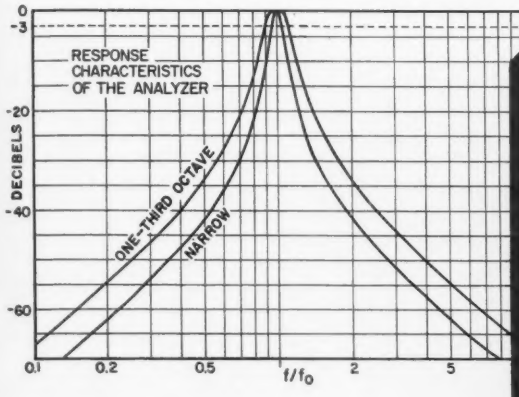
Design Considerations for GEM's. E. K. Liberatore. *Aircraft & Missiles*, Apr., 1960, pp. 32–37. 10 refs. Discussion of ground effect machines, emphasizing annular-jet and plenum-chamber GEM's. Hovering and over-water performances, stability, control, power plants, velocities, and future prospects of the GEM's are considered.

Flight Without Wings. *Bristol Siddeley J.*, 2nd Quart., 1960, pp. 55–58. Discussion of the performance, economics, and application possibilities of the jet-sustained wingless vehicle.

L'Etude Breguet sur les STOLS à Aile Soufflée par les Hélices Breguet "940" et Breguet "941." G. Bruner. *Docaéro*, Nov., 1959, pp. 17–26. Abridged. In French. Discussion of the basic principles of slipstream deflection, description of experimental aircraft, and presentation of some results obtained in wind tunnel and flight tests. A brief description of the Breguet "941" aircraft is also given.

The VTOL Transport—Design Selection. Philip Geddes. *Aircraft & Missiles*, Apr., 1960, pp. 44–47. Discussion of the reasons for the tilt-wing configuration and of the transport and hover cost considerations behind the power-plant choice.

Sound and Vibration Analysis with One Versatile Instrument



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REVIEWS OF *Books*

. . . in the field of aeronautical engineering and space technology

AERODYNAMICS. FLUID MECHANICS

Missile Aerodynamics. Jack N. Nielsen. New York, McGraw-Hill Book Co., Inc., 1960. 450 pp. $12.50.

The present volume attempts to present a rational and unified account of the subject, as well as an adequate mathematical treatment for use in the design of missiles and airplanes. The first and second chapters are purely introductory in nature and include a glossary of special terms and the most common formulas used in missile aerodynamics. The third chapter treats the subject of slender-body theory which the author considers the backbone of missile aerodynamics. In Chapters 4–8 an attempt is made to present missile aerodynamics in an orderly building up of a missile from its component parts, the body alone, the wing panels, the tail, and the control surfaces. The final two chapters treat of drag and stability derivatives. Name and subject indexes conclude the book.

The author is a founder of Vidya, Inc., and was formerly an aeronautical research scientist with NACA.

Proceedings of the 1960 Heat Transfer and Fluid Mechanics Institute Held at Stanford University, June 15–17, 1960. Edited by D. M. Mason, W. C. Reynolds, and W. G. Vincenti. Stanford, Calif., Stanford University Press, 1960. 259 pp. $8.75.

Contents: (1) Magnetohydrodynamically Driven Vortices, W. S. Lewellen. (2) Behavior of Solutions of the Navier-Stokes Equations for a Complete Class of Three-Dimensional Viscous Vortices, C. duP. Donaldson and R. D. Sullivan. (3) An Experimental Study of Gas Dynamics in High Velocity Vortex Flow, J. J. Keyes, Jr. (4) The Behavior of Vortex Motion in an Emptying Container, P. Dergarabedian. (5) Some Applications of Crocco's Integral for the Turbulent Boundary Layer, D. A. Spence. (6) Heat Transfer in the Unsteady Compressible Laminar Boundary Layer on a Flat Plate, N. A. Evans. (7) Boundary Layer Transition Induced by a Vibrating Ribbon on a Flat Plate, F. R. Hama. (8) A New Analytical Model for Boundary Layer Transition, K. G. Sewell. (9) Hot Wire Exploration of Transition on Cones in Supersonic Flow, V. A. Sandborn and R. J. Wisniewski. (10) Explosive Decompression of Water, E. A. Brown, Jr. (11) Heat Transfer around Blunt Bodies with Nonequilibrium Boundary Layers, P. M. Chung and A. D. Anderson. (12) Weak, Nonequilibrium, Diffusive Waves in a Dissociated Gas, F. K. Moore and J. T. Curtis. (13) Separated Supersonic Flows, J. J. Ginoux. (14) Some Effects of Particle-Particle and Particle-Fluid Interaction in Two Phase Flow Systems, R. L. Peskin. (15) An Experimental Study of the Transition from Nucleate to Film Boiling under Zero Gravity Conditions, H. F. Steinle. (16) A Method of Measuring Total Hemispherical Emissivities at Low Temperatures—Results for Pure Iron from 200 to 500 Degrees Rankine, J. A. Brandt, T. F. Irvine, Jr., and E. R. G. Eckert. (17) Minimum Mass Thin Fins for Space Radiators, J. E. Wilkins, Jr. (18) Weight Optimization of Heat Rejection Systems for Space Applications, C. L. Walker, C. R. Smith, and D. G. Gritton.

Hypersonic Flow; Proceedings of the 11th Symposium of the Colston Research Society Held in the University of Bristol, April 6–8, 1959. Edited by A. R. Collar and J. Tinkler. London, Butterworths Scientific Publications; New York, Academic Press, Inc., 1960. 432 pp. $13.50.

Contents: Experimental Results from the N.P.L. Hypersonic Shock Tunnel, B. D. Henshall. Hypersonic Research at the Naval Ordnance Laboratory, R. K. Lobb. Performance Studies for the University of Southampton Hypersonic Gun Tunnel, K.N.C. Bray, L. Pennelegion, and R. A. East. Recent Hyperballistics Research at ARDE—The ARDE Gun Tunnels and Some Experimental Studies of Hypersonic Flow, R. N. Cox. Boundary Layer and Combustion Effects in Shock Tube Flows, D. A. Spence and B. A. Woods. Unsteady Flow at Hypersonic Speeds, J. W. Miles. Hypersonic Research at the LRSI., Saint-Louis, H. Oertel. The Calculation of the Flow Field between a Blunt Body and the Bow Wave, K. W. Mangler. Some Numerical Solutions in Hypersonic Flow, M. D. Van Dyke. Newtonian Flow over a Surface—Theory and Applications, J.-P. Guiraud. Shock Tube Research at the National Physical Laboratory on the Properties of Gases at High Temperatures: Part 1, Ionization Measurements, D. L. Schultz. Shock Tube Research at the National Physical Laboratory on the Properties of Gases at High Temperatures: Part 2, Preliminary Spectrographic Measurements, K. C. Lapworth. Some Aspects of the Design of Hypersonic Vehicles, H. Metcalfe. Some Considerations of Aircraft Configurations Suitable for Long-Range Hypersonic Flight, A. J. Eggers, Jr. Hypersonic Air Breathing Engines, R. R. Jamison.

Calculation of the Aerodynamic Characteristics of Turbine Blading. N. M. Markov. (Leningrad, 1955.) Glen Ridge, N.J., Associated Technical Services, Inc., 1958. 114 pp. $27.50.

Intended for scientists and engineers engaged in the study, design, construction, and testing of turbomachinery, the purpose of this book is to cast some light on the aggregate of problems associated with computing the fundamental aerodynamics characteristics of steam and gas-turbine blading and the actual turbine stage.

The first part considers the calculation of the fundamental aerodynamic characteristics of cascades. In the first chapter, brief data are given concerning their design for two-dimensional flow; the following chapters deal with computation of tip losses in the blading, determination of the effect of finite blade length on energy losses, and deviation of the exit angles of the flow. The final part deals with questions of the fundamental characteristics of the turbine stage and with the effect of rotor rotation on the nature of the flow in the flow passage. The first chapter sets forth general information on the operation of the turbine stage and deals with the design of elementary stages.

In the second chapter, a relationship is established between the characteristics of the elementary stage and the characteristics of the guide and moving blading. Here is considered the problem of agreement between the design and experimentally established characteristics of the stage. The third chapter is devoted to clarifying the effect of rotor rotation on the nature of the movement of the working medium in the boundary layer at the blades, and a method is presented for its computation. The fourth chapter contains sample calculations illustrating the application of the proposed methods of computation.

All of the problems in this book associated with the calculation of the aerodynamic characteristics of the cascade and stage do not entail, in the case of flow past blades, excessively high subsonic flow velocities. Problems of computing aerodynamic characteristics at velocities that are close to critical or supercritical are not treated.

CHEMISTRY

Photochemistry in the Liquid and Solid States; Based on Some of the Papers Presented at a Symposium Held at Endicott House, Dedham, Mass., September 3–7, 1957. Arranged by the Sub-Committee of National Academy of Sciences—National Research Council on the Photochemical Storage of Energy. Edited by Lawrence J. Heidt, Robert S. Livingston, Eugene Rabinowitch, and Farrington Daniels. New York, John Wiley & Sons, Inc., 1960. 174 pp. $6.00.

Contents: (1) Introduction to the Symposium. Photochemistry in the Liquid and Solid States, Farrington Daniels, Lawrence J. Heidt, Robert S. Livingston, and Eugene Rabinowitch.

(2) Photochemical Reactions: Elementary Photoprocesses in Solution, Th. Förster. The Photolysis of Nitrosyl Chloride and the Storage of Solar Energy, Otto S. Neuwirth. Photochemical Production of Some Organic Compounds Under Possible Primitive Earth Conditions, W. Groth. Studies of the Photoinitiated Addition of Mercaptans to Olefins: General Comments on the Kinetics of Mercaptan-Addition Reactions to Olefins Including Cis-Trans Forms, C. Sivertz.

(3) Photosensitized Reactions: Mechanisms of Photosensitization in Solution, George Porter. Investigation of Some Photochemical Electron-Transfer Reactions, C. A. Parker. Photodecomposition of Complex Oxalates. Some Preliminary Experiments by Flash Photolysis, C. A. Parker and C. G. Hatchard. Photoreduction of Methylene Blue: Some Preliminary Experiments by Flash Photolysis, C. A. Parker.

(4) Fluorescence: The Effect of Temperature on Fluorescence of Solutions, E. J. Bowen and J. Sahu. The Sensitized Fluorescence of β-Naphthylamine. A Study in Transfer of Electronic Energy, Jean T. Dubois.

(5) Kinetic Considerations: Kinetic Complications Associated with Photochemical Storage of Energy, Richard M. Noyes.

(6) Role of the Triplet State: The Role of the Triplet State in the Photochemical Auto-Oxidation of Aryl Hydrocarbons, Robert Livingston.

(7) Photochemical Reactions Involving Chlorophyll: Photochemical Redox Reactions and Photosynthesis, E. Rabinowitch. Evidence of Photoreduction of Chlorophyll in Vivo, J. W. Coleman and E. Rabinowitch. Fluorescence-Induction Phenomena in Granular and Lamellate Chloroplasts, J. B. Thomas and J. F. W. Nuboer. The Chloroplast Structure as a Prerequisite for the Functioning of the Natural Light-Energy Converting Mechanism, J. B. Thomas. Energy Storage in Chloroplasts, William Arnold and Helen Sherwood. The Photoreduction of Chlorophyll-a, Thomas T. Bannister. The Absorption Spectra of Hill-Reaction Oxidants, Rudolph J. Marcus, James L. Hatchett, and Kenneth M. Sancier.

(8) Photoreactions in Solids: Energy Storage in Solids as Illustrated by the Silver Halide System, W. West. Photochemical Processes in Thin Single Crystals of Silver Bromide. The Distribution and Behavior of Latent-Image and of Photolytic Silver in Pure Crystals and in Crystals Containing Foreign Cations, W. West and V. I. Saunders. The Ignition of Explosives by Radiation, J. Eggert. A Method for Evaluating Rate Constants in the Jablonski Model of Excited Species in Rigid Glasses, E. H. Gilmore and E. C. Lim. Photoprocesses in Elemental Semiconductors, G. L. Pearson.

(9) Conclusions: Farrington Daniels.

CRYOGENICS

Advances in Cryogenic Engineering, Vol. 5; Proceedings of the 1959 Cryogenic Engineering Conference, University of California, Berkeley, September 2–4, 1959. Edited by K. D. Timmerhaus. New York, Plenum Press, Inc., 1960. 584 pp. $13.50.

Contents: Part A, Applications and Techniques. Cryogenic Engineering Advances in the Space Age, R. F. Blanks and K. D. Timmerhaus. Air Core Cryogenic Magnet Coils for Fusion Research and High-Energy Nuclear Physics Applications, R. F. Post and C. E. Taylor. Design of Large Cryogenic Magnet Coils, C. E. Taylor and R. F. Post. Cryogenic Experience with the 72-Inch Bubble Chamber, H. P. Hernandez. Large-Scale Production, Handling, and Storage of Liquid Hydrogen, P. C. Vander Arend. A Study of the Hazards in the Storage and Handling of Liquid Hydrogen, L. H. Cassutt, F. E. Maddocks, and W. A. Sawyer, Test Equipment and Procedures Used in the Development of Liquid Oxygen-Hydrogen Rocket Engines, R. H. Anschutz, Practical Storage and Distribution of Liquid Hydrogen and Helium, W. E. Perkins and R. J. Frainier.

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Part D, Superinsulation. Development of High-Efficiency Insulation, I. A. Black, A. A. Fowle, and P. E. Glaser. Multiple-Layer Insulation, R. H. Kropschot, J. E. Schrodt, M. M. Fulk, and B. J. Hunter. Engineering Aspects of Heat Transfer in Multilayer Reflective Insulation and Performance of NRC Insulation, M. P. Hnilicka. Characteristics and Applications of Some Superinsulations, P. M. Riede and D. I-J. Wang. Cryogenic Insulation Development, S. T. Stoy.

Part E, Heat Transfer. Heat Transfer to Helium II for Big Differences of Temperature Between Heated Wall and Superfluid Helium Bath, L. Rinderer and F. Haenssler. Transient Phenomena Associated with the Pressurization of Liquid Nitrogen Boiling at Constant Heat Flux, S. K. Fenster, G. J. Van Wylen, and J. A. Clark. Recent Developments of the Reversing Exchanger, M. C. Sze and E. Cimler. Design, Construction, and Testing of a Helium-to-Hydrogen Heat Exchanger, C. C. Wright. Boiling Heat Transfer to Liquid Hydrogen from Flat Surfaces, C. R. Class, J. R. DeHaan, M. Piccone, and R. B. Cost. Nucleate- and Film-Boiling Studies with Liquid Hydrogen, U. H. von Glahn and J. P. Lewis.

Part F, Design and Application. On the Evacuation of Plastic Foams to Reduce Their Thermal Conductivity, L. R. Stoecker. The Venturi Tube as a Liquefied-Gas Flow Measuring Device, J. R. Purcell, A. F. Schmidt, and R. B.

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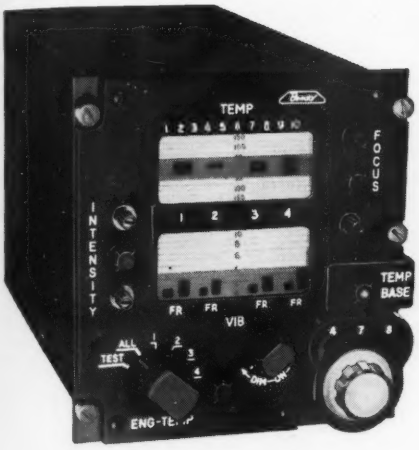

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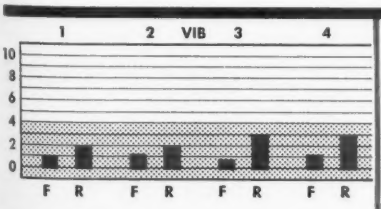
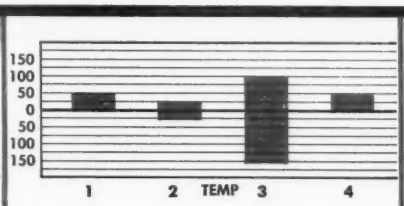
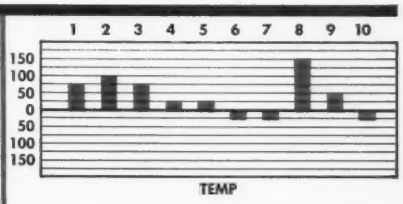


Vibration indication for four engines with front and rear pickups on each. Height of display indicates total vibration displacement.



Temperature "all" display indicating maximum and minimum temperatures above and below temperature datum for four engines.



Temperature for single engine indicates all thermocouples indicating temperature above or below temperature datum reference.

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Part L, Additional Papers. An Improved DC Power Regulator, R. D. Goodwin. Vacuum Gaskets for Use at 20°K, J. E. Harlow, E. L. Murley, and H. L. Laquer.

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EQUIPMENT, HYDRAULIC & PNEUMATIC

Fluid Power Control. Edited by John F. Blackburn, Gerhard Reethof, and J. Lowen Shearer. Cambridge, Mass., The Technology Press of M.I.T.; New York, John Wiley & Sons, Inc., 1960. 710 pp. $17.50.

Contents: Chapter 1, Fluid Power, J. F. Blackburn. Chapter 2, Properties of Fluids, Gerhard Reethof. Chapter 3, Fundamentals of Fluid Flow, A. H. Stenning and J. L. Shearer. Chapter 4, Characteristics of Positive-Displacement Pumps and Motors, Gerhard Reethof. Chapter 5, Fluid-Power Transmission, F. D. Ezekiel and H. M. Paynter. Chapter 6, On Valve Control, J. F. Blackburn. Chapter 7, Pressure-Flow Relationships for Hydraulic Valves, J. F. Blackburn. Chapter 8, Pressure-Flow Characteristics of Pneumatic Valves, F. D. Ezekiel and J. L. Shearer. Chapter 9, Valve Configurations and Constructions, S.-Y. Lee and J. F. Blackburn. Chapter 10, Steady-State Operating Forces, J. F. Blackburn. Chapter 11, Electromagnetic Actuators, R. H. Frazier. Chapter 12, Transient Forces and Valve Instability, J. F. Blackburn, J. L. Coakley, and F. D. Ezekiel. Chapter 13, Electrohydraulic Actuation, S.-Y. Lee, and J. L. Shearer. Chapter 14, The Analysis of the Dynamic Performance of Physical Systems, J. A. Hrones. Chapter 15, Hydraulic Drives, J. L. Shearer. Chapter 16, Pneumatic Drives, J. L. Shearer. Chapter 17, Closed-Loop Systems, Gerhard Reethof and J. L. Shearer. Chapter 18, Power Steering, T. E. Hoffman. Chapter 19, Comparison of Hydraulic and Pneumatic Servomechanisms, J. L. Shearer. Chapter 20, Analysis and Design of Servomotors Operating on High-Pressure Hot Gas, Gerhard Reethof.

LAWS & REGULATIONS

International Control of Nuclear Maritime Activities. Lee M. Hydeman and William H. Berman. Ann Arbor, The University of Michigan, 1960. 384 pp. Bound, $6.00; paper, $4.50.

The present volume treats only briefly many of the technical and legal problems raised by nuclear maritime activities. The book is limited to problems of health and safety control and only incidentally mentions matters of liability.

Contents: Part 1, Hazards and Existing Controls: (1) Radiation and the Marine Environment. (2) Transport of Radioactive Materials. (3) Sea Disposal of Radioactive Wastes. (4) Nuclear-Powered Vessels.

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MANPOWER

Britain's Scientific and Technological Manpower. George Lewis Payne. Stanford, Calif., Stanford University Press; London, Oxford University Press, 1960. 466 pp. $8.50.

This report, which was prepared for the President's Committee on Scientists and Engineers, presents a general review of Britain's scientific and engineering manpower—its postwar strengths and deficiencies, and present supply; the expected future demand, and the steps being taken or planned to meet this demand, including data from the latest manpower survey of 1959; and also the projections of need for 1962 and 1966. Mr. Payne is with the Office of Research Planning, National Institutes of Health.

Contents: Introductory Notes. (1) The Problem and its Background. (2) Technical Manpower and Its Employment in 1956. (3) Current and Expected Demand for Scientists and Engineers. (4) The Secondary Schools. (5) The Universities. (6) Nonuniversity Channels to a Technical Education. (7) Expansion of Educational Facilities. (8) Expansion of Educational Opportunities. (9) Research and Development. (10) Technological Expansion and the Social Scene. Appendix 1. Appendix 2. References. Selected Bibliography of Official Documents and Publications Concerning British Scientific and Technological Manpower and Education. Index.

MATHEMATICS

Boundary Problems in Differential Equations; Proceedings of a Symposium Conducted by the Mathematics Research Center, University of Wisconsin, Madison, April 20–22, 1959. Edited by Rudolph E. Langer. (Mathematics Research Center, U.S. Army and University of Wisconsin, Publication No. 2.) Madison, University of Wisconsin, 1960. 324 pp. $4.00.

Contents: Boundary Problems of Linear Differential Equations Independent of Type, K. O. Friedrichs. Numerical Estimates of Contraction and Drag Coefficients, Paul R. Garabedian. Complete Systems of Solutions for a Class of Singular Elliptic Partial Differential Equations, Peter Henrici. Application of the Theory of Monotonic Operators to Boundary Value Problems, Lothar Collatz. Upper and Lower Bounds for Quadratic Integrals, and, at a Point, for Solutions of Linear Boundary Value Problems, J. B. Diaz. Error Estimates for Boundary Value Problems Using Fixed-Point Theorems, Johann Schröder. On a Unified Theory of Boundary Value Problems for Elliptic-Parabolic Equations of Second Order, Gaetano Fichera. Factorization and Normalized Iterative Methods, Richard S. Varga. Some Numerical Studies of Iterative Methods for Solving Elliptic Difference Equations, David Young and Louis Ehrlich. Albedo Functions for Elliptic Equations, Garrett Birkhoff. A Numerical Method for Analytic Continuation, Jim Douglas, Jr. Stress Distribution in an Infinite Elastic Sheet with a Doubly-Periodic Set of Equal Holes, W. T. Koiter. Some Stress Singularities and Their Computation by Means of Integral Equations, Hans F. Bueckner. Boundary Value Problems in Thermoelasticity, Ian N. Sneddon. Some Numerical Experiments with Eigenvalue Problems in Ordinary Differential Equations, Leslie Fox. Dynamic Programming, Invariant Imbedding, and Two-Point Boundary Value Problems, Richard Bellman. Remarks About the Rayleigh-Ritz Method, Richard Courant. Free Oscillations of a Fluid in a Container, B. Andreas Troesch. A Variational Method for Computing the Echo Area of a Lamina, Calvin H. Wilcox.

Modern Probability Theory and its Applications. Emanuel Parzen. New York, John Wiley & Sons, Inc., 1960. 464 pp. $10.75.

The aim of the author is to present the major ideas of modern probability theory without assuming that the reader knows the advanced mathamatics necessary for a rigorous discussion.

The first six chapters constitute a one-quarter course in elementary probability theory at the sophomore or junior level. For the study of these chapters, the student need have only one year of college calculus. Students with more mathematical background could also cover Chapters 7 and 8. Chapters 9 and 10 constitute an introduction to the limit theorems of probability theory and to the role of characteristic functions.

These chapters provide careful and rigorous derivations of the law of large numbers and the central limit theorem, and contain many new proofs. The book also contains a large number of exercises in the form of numerical problems.

Emanuel Parzen is Associate Professor of Statistics, Stanford University.

MECHANICS

Progress in Solid Mechanics, Vol. 1. Edited by I. N. Sneddon and R. Hill. Amsterdam, North-Holland Publishing Co.; New York, Interscience Publishers, Inc., 1960. 448 pp. $15.50.

The present volume is the first in a series of review articles mainly concerned with recent theoretical studies in solid mechanics. To preserve flexibility, the series scope has not been precisely defined. The main emphasis in future volumes will be on the basic principles and mathematical techniques of continuum mechanics in all aspects.

Contents: Viscoelastic Waves, S. C. Hunter. Matrices of Transmission in Beam Problems, K. Marguerre. Dynamic Expansion of Spherical Cavities in Metals, H. G. Hopkins. General Theorems for Elastic-Plastic Solids, W. T. Koiter. Dispersion Relations for Elastic Waves in Bars, W. A. Green. Thermoelasticity. The Dynamical Theory, P. Chadwick. Continuous Distributions of Dislocations, B. A. Bilby. Asymmetric Problems of the Theory of Elasticity for a Semi-Infinite Solid and a Thick Plate, R. Muki. References. Author Index. Subject Index.

METEOROLOGY

The Atmosphere and the Sea in Motion; Scientific Contributions to the Rossby Memorial Volume. Edited by Bert Bolin. New York, The Rockefeller Institute Press in Association with Oxford University Press, 1959. 509 pp. $15.

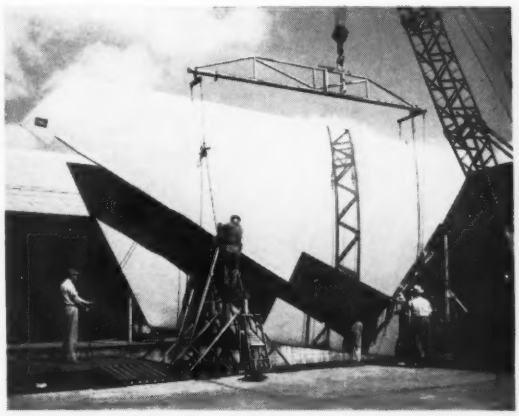
Contents: Current Problems in Meteorology C.-G. Rossby. The Young Carl-Gustaf Rossby, T. Bergeron. Carl-Gustaf Rossby, the Organizer, H. R. Byers. Publications by Carl-Gustaf Rossby.

The Sea in Motion: The Recent Warming of the North Atlantic, J. Bjerknes. On the Thermal Unrest in the Ocean, B. Haurwitz, H. Stommel, and W. H. Munk. On the Vertically Integrated Mass Transport in the Oceans, P. Welander. Wind und Massenverteilung als Urasache der Meeresströmungen (Wind and Mass Distribution as the Origin of Ocean Current) (in German), W. Hansen. The Antarctic Convergence—or Divergence? H. Wexler. Climatic Records on the Ocean Floor, G. O. S. Arrhenius.

Distribution of Matter in the Sea and Atmosphere: Changes in the Carbon Dioxide Content of the Atmosphere and Sea Due to Fossil Fuel Combustion, B. Bolin and E. Eriksson. Salinity and the Residence Time of Subtropical Oceanic Surface Water, R. B. Montgomery. The Circulation of Some Atmospheric Constituents in the Sea, E. Eriksson. Meteorological Aspects of Oxidation Type Air Pollution, M. Neiburger.

The General Circulation of the Atmosphere: A Method for Calculation of Infrared Flux for Use in Numerical Models of Atmospheric Motion, L. D. Kaplan. On the Theory of the General Circulation of the Atmosphere, J. Charney. Some Results Concerning the Distribution and Total Amount of Kinetic Energy in the Atmosphere as a Function of External Heat Sources and Ground Friction, R. Fjørtoft. On the Maintenance of Kinetic Energy in the Atmosphere, E. Palmén. Explication dynamique de la circulation générale de l'atmosphère sur la base des idées de Rossby. (Dynamic Explanation of General Atmospheric Circulation According to Rossby's Concepts) (in French), P. Queney. On the Selective Role of the Motion Systems in the Atmospheric General Circulation, J. van Mieghem, P. Defrise, and J. van Isacker. Persistence of Mid-Tropospheric Circulations between Adjacent Months and Seasons, J. Namias. The Abrupt Change of Circulation over the Northern Hemisphere during June and October, T.-C. Yeh, S.-Y. Dao, and M.-T. Li. A Method of Solving the Nonlinear Differential Equations of Atmospheric Tides with Applications to an Atmosphere of Constant Temperature, C. L. Pekeris and Z. Alterman.

Characteristic Features of Atmospheric Motion: On the Formation of Fronts in the Atmosphere, A. Eliassen. Synoptic Comparisons of Jet Stream and Gulf Stream Systems, C. W. Newton. On Hydrodynamic Instability Caused by an Approach of Subtropical and Polar-front Jet Stream in Northern Latitudes Before the Onset of Strong Cyclogenesis, F. Defant. A Solution of the Nonlinear Vorticity Equation, G. W. Platzman. On the Behavior of Baroclinic Waves, J. Holmboe. Some Statistical Aspects of the Dynamical Processes of Growth and Occlusion in Simple Baroclinic Models, P. D. Thompson. The Propagation of Frequency in Experimental Baroclinic Waves in a Rotating Annular Ring, D. Fultz and R. Kaylor. A Laboratory Model of Air Flow over the Sierra Nevada Mountains, R.



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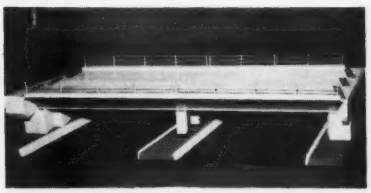

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R. Long. On Production of Kinetic Energy from Condensation Heating, H. Riehl. Physics of Winter Precipitation in the Desert, H. R. Byers. Dynamics of Convective Vortices and Eye Formation, H. L. Kuo. The Evolution of a Convective Element: A Numerical Calculation, J. S. Malkus and G. Witt.

Weather Forecasting: Methods in Scientific Weather Analysis and Forecasting. An Outline in the History of Ideas and Hints at a Program, T. Bergeron. Hemispheric Nondivergent Barotropic Forecasting, G. P. Cressman. Ein numerisches Experiment mit den primitiven Gleichungen (A Numerical Experiment with Primitive Equations) (in German), K. Hinkelmann. An Example of Non-Linear Computational Instability, N. A. Phillips. On the Equivalency of Formulations of Weather Forecasting as an Initial Value Problem and as an "Evolution" Problem, C. C. Koo.

POWER PLANTS

Propulsion Systems for Space Flight. William R. Corliss. New York, McGraw-Hill Book Co., Inc., 1960. 300 pp. $10.

This book is at once a survey and an evaluation of the many "space engines" developed and proposed for transporting matter about the universe. The bulk of the subject matter has been expanded and brought up to date from a survey course on advanced propulsion concepts which the author presented at the General Electric Co. in 1958. An effort has been made to emphasize the more advanced or "exotic" types; therefore the focus of interest is chiefly on nuclear and electrical propulsion systems rather than chemical systems. The requirements of various space missions are compared with the abilities of the different propulsion systems, which include nuclear and thermonuclear engines, plasma devices, ion drives, nuclear-particle generators, photonic drives, solar sails, and natural force fields, as well as the conventional air-breathing boosters and chemical rockets. The book closes with a glossary of terms associated with space propulsion, a list of symbols, an extensive bibliography divided into categories which parallel the chapter material, and an index.

The author is with the Nuclear Division, The Martin Company.

SCIENCE & ENGINEERING

Proceedings of the Frontiers of Science and Engineering Symposium; Held at Los Angeles, September 16–17, 1959. Co-Sponsored by the Institute of the Aeronautical Sciences and the University of California. New York, The IAS, 1960. 132 pp. Members, $5.00; nonmembers, $10.

Contents: Space Environment, S. Chapman Astromechanics, S. Herrick. Biomedicine, A. H. Schwichtenberg. Free Radicals, J. W. Moyer. Solid State Physics, J. A. Krumhansl. Cryogenics, J. R. Pellam. Operations Research, G. Kimball. Transports, G. Schairer. Military Aircraft, E. Heinemann. Photography, Roderic Scott. Instrumentation and Inertial Systems, C. S. Draper. Nuclear Power, E. Teller.

SPACE TRAVEL. ROCKETS

Proceedings of the National Specialists Meeting on Guidance of Aerospace Vehicles, Boston, May 25–27, 1960. Sponsored by the Institute of the Aeronautical Sciences with the Cooperation of the Boston Section, IAS. New York, The IAS, 1960. 250 pp. Members, $5.00; nonmembers, $10.

Contents: Command and Data Link for an Astronomical Satellite, Leland L. Antes. Some Considerations of Guidance and Control Techniques for Coplanar Orbital Rendezvous, Eugene Harrison. The Long-Time Satellite Rendezvous Trajectory, L. W. Spradlin. Guidance and Control of Point Return Vehicles, J. H. Lowry, Jr., and C. D. Buehrle. Horizon Sensors for Vertical Stabilization of Satellites and Space Vehicles, Morris H. Arck and M. Monty Merlen. An Accurate Determination of Attitude by Optical Means for Applications in Space Vehicles, G. von Pahlen-Fedoroff. Application of Optical Techniques to Interplanetary Navigation, Wesley J. Haywood, Jr. A Free Reaction Sphere Satellite Attitude Control System, Ralph D. Ormsby. A Magnetic Support for Floated Inertial Instruments, P. J. Gilinson, Jr., W. G. Denhard, and R. H. Frazier. Limit-Cycle Efficiency of On-Off Reaction Control Systems, George W. Freeman. Methods of Analysis of a Control System for a Large Flexible Missile, David R. Lukens. Pilot Control of Space Vehicle Tumbling, James W. Useller and Joseph S. Algranti. V/H Satellite Attitude Control, P. A. Button, P. E. Mallory, and S. B. Boor. Control Development for Jet VTOL, James A. O'Malley, Jr. In-Flight Measurement of Human Operator Alertness, Thomas B. Sheridan. A Discussion of the Design of a Propulsion and Stabilization System for Man in a Cosmonotic Environment, J. B. Griffin, F. T. Gardner, and M. L. Barnett. Hovering and Longitudinal Dynamics of the Ground Effect Machine with Derivations of the Stability Derivatives for Vertical Motion, Tsun-Ying Feng. Design Principles for a Control Computer for Space Guidance, R. L. Alonso and J. Halcombe Laning, Jr. Trajectory Problems in Cislunar Space, George Shapiro. Terminal Guidance for Lunar and Planetary Probes, Robert H. Grube. Differential Correction Method of Interplanetary Navigation, Harvey G. Safren. A Study of an Adaptive Control System Using a Digital Simulation, T. R. Benedict, H. R. Leland, W. C. Schultz, and M. G. Spooner. Application of Adaptive Control Techniques to Aero/Space Vehicles, W. F. O'Neil and M. J. Abzug. A Method of Graphical Trajectory Analysis, A. S. Boksenbom. Prediction of Anisoelastic and Vibropendulous Effects on Inertial Navigation System Performance in Linear Random Vibration Environments, Samuel Leshnover.

Physics and Medicine of the Atmosphere and Space; Proceedings of the 2nd International Symposium on the Physics and Medicine of the Atmosphere and Space, San Antonio, Tex., November 10–12, 1958. Edited by Otis O. Benson, Jr., and Hubertus Strughold. Sponsored by the School of Aviation Medicine, Aerospace Medical Center (ATC), Brooks AFB, Tex. Arranged by Southwest Research Institute, San Antonio, Tex. New York, John Wiley & Sons, Inc., 1960. 645 pp. $12.50.

Contents: (1) On the Radiation Hazards of Space Flight, J. A. Van Allen. (2) Aeronomic Chemical Reactions, M. Nicolet. (3) Meteoritic Material in Space, F. L. Whipple. (4) Effects of Interplanetary Dust and Radiation Environment on Space Vehicles, S. F. Singer. (5) The Electromagnetic Environment of the Atmosphere and Nearer Space, W. Dieminger. (6) Upper Atmosphere Properties Based on Rocket and Satellite Data, H. K. Kallmann. (7) Composition of the Upper Atmosphere, J. W. Towsend, Jr. (8) The Gravitational Environment in Space, H. Strughold and O. L. Ritter. (9) Physical and Medical Aspects of Ozone, H. G. Clamann. (10) Solar Influences on the Extra-Atmospheric Radiation Field and Their Radiobiological Implications, H. J. Schaefer and A. Golden. (11) Effects of High-Altitude Cosmic Radiation on Barley Seeds, J. Eugster and D. G. Simons. (12) Radiobiological Studies with Accelerated Heavy Ions, C. A. Tobias and T. Brustad. (13) The Weight Limitations and Capabilities in Rocket Propulsion for Manned Space Operations, B. A. Schriever. (14) A Survey of Possible Propulsion Systems, L. R. Shepherd. (15) Space Travel with Electric Propulsion Systems, E. Stuhlinger. (16) The Timing of Satellite and Space Probe Launchings, W. von Braun. (17) The Rocket-Boosted Glider as a Space Vehicle, E. T. Welmers. (18) Manned Orbital and Lunar Space Vehicles, K. A. Ehricke. (19) Deceleration During Entry into Planetary Atmospheres, D. R. Chapman. (20) Parameters of Human Adaptation to Altitude, A. Hurtado and R. T. Clark, Jr. (21) Medical Experimentation in a Sealed Cabin Simulator, G. R. Steinkamp and W. R. Hawkins. (22) Problems of Metabolism in Sealed Cabins, H. G. Clamann. (23) The Use of Photosynthesis in a Closed Ecological System, J. Myers. (24) Nutrition of Long Space Voyages, R. G. Tischer. (25) Psychological Problems of Space Flight, G. T. Hauty. (26) Psychophysiologic and Medical Studies of Weightlessness, S. J. Gerathewohl and J. E. Ward. (27 Biological Aspects of Nuclear Propulsion, John E. Pickering. (28) Biomedical Aspects of Orbital Flight, W. R. Lovelace II and A. S. Crossfield. (29) Human Tolerance to Accelerations of Space Flight, J. P. Stapp. (30) Perception and Reaction Times, H. W. Rose. (31) Time Dilation and the Astronaut, E. R. Goltra. (32) Introduction to the Problem of Escape and Rescue During Space Operations, P. A. Campbell. (33) Escape at Launching and in the Atmosphere from a Space Vehicle, R. M. Stanley. (34) Rescue from Space by a Secondary Vehicle, K. A. Ehricke. (35) Rescue and Retrieve Space Missions, N. V. Petersen. (36) Survival in Space: The Vehicle—Combined Requirements, A. M. Mayo. (37) The Physics of the Sun, W. O. Roberts. (38) The Environments of the Moon and the Planets, G. P. Kuiper. (39) The Physical Environment on Mars, G. de Vaucouleurs. (40) Survival of Terrestrial Microorganisms under Simulated Martian Conditions, J. D. Fulton. (41) Interplanetary Travel from the Viewpoint of the Engineer, G. P. Sutton. (42) Interplanetary Space Flight from the Viewpoint of the Physician, H. Strughold.

Figures of Equilibrium of Celestial Bodies; With Emphasis on Problems of Motion of Artificial Satellites. Zdeněk Kopal. (Mathematics Research Center, U.S. Army and University of Wisconsin, Publication No. 3.) Madison, University of Wisconsin, 1960. 135 pp. $3.00.

The subject of this work is the investigation of the figures of equilibrium of self-gravitating compressible fluids, and of the attraction exerted by them at any external point. The aim is to provide a coherent account of the present state of Clairaut's theory of the equilibrium of distorted self-gravitating fluids, complete up to and including the terms of second order. Chapter 2 contains a brief account of the first-order theory. Chapter 3 is devoted to the second-order effects of rotation and tides, while Chapter 4 deals with the interaction between rotation and tides. The fifth and final chapter contains a discussion of the free and forced oscillations of fluid bodies, with special regard to the possibility of resonance between them. The volume is concluded by bibliographical notes containing references and historical comments on previous work in this field.

The author is Professor and Head, Department of Astronomy, University of Manchester, and a member of the Mathematics Research Center, U.S. Army.

Advances in the Astronautical Sciences, Vol. 5; Proceedings of the 2nd Western National Meeting of the American Astronautical Society, Los Angeles, August 4–5, 1959. New York, Plenum Press, Inc., 1960. 356 pp. $8.00.

Contents: Part 1, Human Factors. Human Factors in Probing Outer Space, H. A. Imus. Shielding and Nuclear Propulsion, R. F. Trapp and E. B. Konecci. The Reaction Control Simulator, W. Kuehnegger. Human Factors in Spacecraft Technology, R. N. deCallies.

Part 2, Space Mechanics, Control and Guidance. Fuel Requirements for Crude Interplanetary Guidance, J. V. Breakwell. Guidance Requirements for Interplanetary Flight, F. H. Kierstead, Jr. Satellite Orbit Control System, M. C. Fitz-Gibbon. Scientific Significance of Deep Space Exploration, E. T. Benedikt. Dynamic Response Surfaces for Nonlinear Equations of Rocket-Powered Flight, R. E. Ross.

Part 3, Advanced Propulsion and Power. Design Optimization of Thermal Radiators for Space Vehicles, R. A. Cornog. Solar Photovoltaic Power Sources for Space Vehicles, J. D. Sailor. The Problem of Electrical Neutrality in Ion Beams, E. Fisher. The Magnetic Pinch Engine for Space Flight, A. E. Kunen and W. McIlroy.

Part 4, Astronautical Systems and Space Vehicle Design. Round-Trip Trajectories for Mars Observation, P. G. Johnson and R. L. Smith. A Systematic Approach to a Matrix of Space Research Vehicles, O. W. Nicks. The Influence of Space Research Vehicles, O. W. Nicks. The Influence of Launch Conditions on the Friendly Rendezvous of Astrovehicles, R. S. Swanson and N. V. Petersen. Effect of Reentry Technique on the Design of a Space Vehicle, J. Stalony-Dobrzanski.

Part 5, Space Communication and Instrumentation. Global Communication Using Passive or Active Satellite Relay Stations, F. Vilbig. Requirements for Data Transmission from a Martian Reconnaissance Vehicle, C. H. Child. Measuring Amplitude and Phase, N. R. Goodman. Design Techniques for Space Television, A. J. Viterbi.

Part 6, Lunar and Planetary Environment. The Origin of the Gravitational Field, F. E. Alzofon. The Lunar Gravitational Potential, I. Alexandrov. An Analytical Method for Determining the Orbital Characteristics of a Nonlifting Body Which Passes Through the Lower Atmosphere of a Planet, G. S. Gedeon. Lunar and Terrestrial Atmospheres, R. Jastrow. Shock Tube Experiments Simulating Entry into Planetary Atmospheres, R. W. Rutowski and K. K. Chan.

Space Facts; A Handbook of Basic and Advanced Space Flight and Environmental Data for Scientists and Engineers. Philadelphia, Missile and Space Vehicle Department, General Electric Co., 1960. 60 pp.

It includes physical data relating to selected stars, the sun, the planets, the earth, and planetary satellites. Also discussed are the physics of space flight, navigation and guidance, space communications, and bioastronautics and human factors.

STRUCTURES

Hyperstatic Structures, Vol. 1; An Introduction to the Theory of Statically Indeterminate Structures. J. A. L. Matheson. With chapters by N. W. Murray and R. K. Livesley. London, Butterworths Scientific Publications; New York, Academic Press, Inc., 1959. 474 pp. $15.50.

Contents: Lists of Symbols. (1) Hyperstatic or Statically Interminate Structures. (2) The Energy Theorems of Structural Analysis. (3) General Theorems for Linear Elastic Structures. (4) General Methods for Linear Hyperstatic Structures. (5) Moving Loads on Structures. (6) Frames with Rigid Joints. (7) Arches. (8) Stability of Struts and Frameworks. (9) Matrix Methods. Appendix A: Non-Uniform Beams. Appendix B: Notes on the Design of Hyperstatic Structures. Name Index. Subject Index.

Dr. Matheson is Beyer Professor of Engineering, University of Manchester.

THERMODYNAMICS

Radiation Pyrometry and Its Underlying Principles of Radiant Heat Transfer. Thomas R. Harrison. New York, John Wiley & Sons, Inc., 1960. 234 pp. $12.

The primary purpose of this book is to furnish sufficient information concerning radiation pyrometry to enable practicing engineers to use radiation pyrometers under a wide variety of conditions. The pertinent ramifications of the laws of emission, reflection, and transmission of thermal radiation are treated in Chapters 1, 2, and 3, and in some of the appendixes. Chapter 4 discusses many of the characteristics and design features of radiation pyrometers. Chapter 5 deals with the application of emittance corrections, and Chapter 6 contains tables that include radiation pyrometer calibrations, optical characteristics of various substances, some radiation functions, and certain mathematical relationships of application in radiation pyrometry.

The author is Technical Adviser for the Brown Instrument Division, Minneapolis-Honeywell Regulator Co.